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**Mathematics Anxiety in Student
Nurses.**

Submitted in part-fulfilment of

Doctorate in Education (EdD)

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Abstract

Mathematics anxiety is a significant problem amongst student nurses and can potentially have a negative impact on an individual's ability to perform safely and effectively in practice. This creates problems for those involved in developing undergraduate nursing programmes and supporting the students in their learning. This study explores mathematics anxiety in student nurses in the belief that a better understanding may help to develop better strategies to prevent or reduce anxiety, or help to address the problems that it creates.

The study employs a Mixed Methods design and consists of two stages. The first is a survey of one cohort of student nurses to determine the extent of mathematics anxiety within the cohort. A data collection tool was developed and 423 completed questionnaires were returned. A total of 68.1% of students reported moderate to very high levels of mathematics anxiety. Statistical tests were performed to determine any differences due to gender, age, educational history and previous mathematics qualifications.

The second stage was in-depth narrative interviews with students who reported high or very high levels of mathematics anxiety, exploring any experiences they associated with when, why and how that anxiety developed. Nine students were interviewed and several themes emerged including the language of mathematics, the students' inherited legacy of mathematics, implications for practice and interventions that students found most helpful.

The results of the study suggest that for many students their mathematics anxiety did not arise from traumatic experiences with aggressive mathematics teachers as is often purported, but as a result of the way in which they were taught mathematics, a lack of a positive working relationship with their teachers or a lack of concern or support from their family. The findings also suggest that for some students, previous successes in mathematics have not increased their confidence in their ability, possibly due to their perceptions of it as a cold and remote subject and the surface approach to learning that they have adopted in order to pass mathematics examinations.

Chapter 1: Introduction

It is widely recognised that mathematics anxiety is a significant problem amongst student nurses (Hutton 1998a, Sabin 2001, Glaister 2007) and this anxiety has a potentially negative impact on an individual's ability to perform safely and effectively in practice. With the move of nurse education into Higher Education Institutions, this has created problems for those involved in developing undergraduate programmes leading to professional qualifications and the staff supporting the students in their learning.

I am a Registered Nurse and Senior Academic in a large health faculty and I have direct responsibility for managing a department that provides academic support for healthcare students, including numeracy support. The responsibility of this department is not to teach specific nursing skills such as medication management, that is the remit of the course team, but to provide support for students who struggle with the underpinning numeracy skills required to perform skills such as medication calculations. Within the department, there are two other academics involved in numeracy support, one of which is a full-time numeracy support tutor. The department is quite unusual in that it is faculty-based and caters only for the students within the Faculty of Health. Most universities manage mathematics support via a central department which has to cater for the needs of the whole university, a wide range of subject disciplines, and varied applications of mathematical principles. Our faculty-based department has the advantage of being able to focus specifically on the support needs of healthcare students, which does include a great deal of numeracy support. I am not a mathematician or a

mathematics teacher, but I do have sufficient confidence in my own numeracy skills to feel able to support healthcare students in developing their numeracy skills related to practice. As a result of my experience in this field, I am well aware that anxiety underpins many students' perceived lack of mathematics ability, and that this can have a significant impact on their ability to perform safely and confidently in practice.

One might normally assume that an individual's achievement of success in a subject would naturally lead to an increase in their self confidence in that subject (Parsons et al 2011). However this does not always seem to be the case for student nurses and mathematics. All student nurses have achieved previous success in mathematics by virtue of meeting the entry requirements for the programme (GCSE mathematics grade C or equivalent), and yet experience suggests that many still have high levels of mathematics anxiety, even in relation to basic numeracy and arithmetic skills, and some require a great deal of support to pass the numeracy assessments that are an intrinsic part of the programme.

Mathematics anxiety is an important issue for student nurses. The education and training of student nurses is governed by the Nursing and Midwifery Council (NMC) who set a number of standards which must be achieved in order for students to register as qualified practitioners on completion of their programme of study. The NMC (2010) requires practitioners to be safe and competent in a wide range of skills including numeracy, particularly in relation to the safe and competent administration of medication. The accurate calculation of medication dosages has obvious implications for

patient safety, with errors being potentially harmful or even fatal. Coben (2000) explains that to be numerate means to be competent, confident, and comfortable with one's judgements related to the use of mathematics. When numeracy skills are needed by nurses in the clinical environment, they need to know what mathematics to use and how to use it. However, if mathematics anxiety leads to a lack of confidence in one's mathematical ability, and confidence is an important factor of numerical competence (Coben 2000), then mathematics anxiety amongst student nurses is a problem that needs to be addressed.

Whilst there is extensive recent and current research aimed at developing strategies to overcome mathematics anxiety (Farrand et al 2006, Moriarty et al 2008, Bull 2009), and developing resources to support the application of mathematical skills to nursing practice (Weeks et al 2013a), the origins of mathematics anxiety are a relatively unexplored topic. This study explores the issue of mathematics anxiety amongst student nurses in the belief that a better understanding of the causes of this anxiety may help to develop strategies to prevent or reduce it as well as more effectively address the problems that it creates. The key area for exploration is the causes of mathematics anxiety, and the research questions that are addressed by this study are:-

- When, why and how does mathematics anxiety develop in some student nurses?
- What can be done to prevent, counteract or overcome this anxiety in order to improve student nurses' confidence in their numeracy skills?

The term Mathematics Anxiety has been chosen for this study because, whilst it is recognised that the skills that student nurses need are numeracy skills, the students who took part in the study generally focussed on maths, particularly when reflecting on their previous experiences and it became clear that it was mathematics generally, rather than numeracy specifically, to which they related their anxieties.

Initially an extensive review of the literature was undertaken as is reflected in Chapter 2. This starts by defining the terms mathematics and outlining the different philosophies of mathematics education. An explanation of anxiety is then followed by a discussion of mathematics anxiety and its implications for student nurses. This discussion is structured around the research questions and links to issues related specifically to mathematics anxiety within healthcare, and particularly to nurses and student nurses. Chapter 3 outlines the research design and methodology. The study consists of two stages: a survey stage and an interview stage. The survey involved one cohort of student nurses (518 students) to determine the extent of mathematics anxiety within that cohort and to identify students with high levels of anxiety for potential inclusion in the interview stage. The Interview stage involved in-depth narrative interviews with nine students who demonstrated high levels of mathematics anxiety to explore any experiences they associated with why, when and how that anxiety developed. Chapter 4 outlines the initial study which was essentially a review and pilot of the data collection tool that was to be used for the survey phase of the study. Chapters 5 and 6 outline the survey and interview stages of the study. Several themes emerged including the language that we use in relation to mathematics, the students' inherited

legacy of mathematics, their anxieties related to mathematics, mathematics in the practice environment and what students found helpful in helping them overcome their anxiety. Chapter 7 is a discussion of the findings and is structured around these themes. Finally Chapter 8 outlines my conclusions and recommendations and suggests that the findings of this small study have potential implications for the ways in which we provide numeracy support in the future.

Chapter 2: Literature Review

This chapter is a review of relevant literature related to the issue of mathematics anxiety particularly in relation to student nurses. In order to explore the origins of mathematics anxiety in student nurses, the research questions to be addressed were

1. When, why and how does mathematics anxiety develop in some student nurses?
2. What can be done to prevent, counteract or overcome this anxiety in order to improve student nurses' confidence in their numeracy skills?

The Search Strategy

According to Robson (2011 p.52) the purpose of a literature review within 'Real World Research' is to;

- Put together the literature on a topic of interest
- Expose gaps in the literature and identify the principle areas of dispute and uncertainty
- Identify general patterns of findings
- Juxtapose studies with apparently conflicting findings to help explore explanations of discrepancies
- Define terminology or identify variations in definitions
- Help to identify appropriate research methodologies and instruments

For this study, which I believe falls into the category of Real World Research, the purpose of the literature review was to put together the literature on the topic of mathematics anxiety. Maxwell (2006) emphasises the importance of the relevance of the material rather than striving for comprehensiveness, but the review needed to be as extensive as possible in order to expose any potential gaps in the literature that might be addressed by this study. Green and Thorogood (2014) argue that the notion of identifying gaps in the literature is a rather limited one, because as gaps become filled others are revealed. Nonetheless it was important to ascertain as far as possible whether answers to my research questions already existed in the literature. The literature review did also enable me to define the terminology related to mathematics and anxiety and to identify alternative key words and variations in definitions, particularly related to mathematics. Green and Thorogood (2014) also argue that, as well as a means of adding to our store of empirical knowledge, the literature review is an essential element of learning and developing methodological skills. Indeed the mathematics anxiety assessment tool that subsequently formed the basis of the data collection tool used in the survey stage of this study emerged from the literature related to mathematics anxiety, as did the use of narrative interviews as a method.

The research questions had been determined before the commencement of the literature review although I was prepared to change or amend them as a result. There were one or two a priori concepts such as mathematics anxiety and confidence, but many new concepts emerged as the study progressed, particularly related to educational theory and these enabled the literature

review to be further developed. It was never my intention to restrict reading to the start of the study, but to develop the literature review incrementally in this way as new themes and concepts emerged.

Therefore an initial literature search was undertaken using the Education Resources Information Centre (ERIC) and Cumulative Index of Nursing and Allied Health Literature (CINAHL) databases. Several texts were sourced, read and then further sources identified within those texts were followed up, read and so on. The cited in function of Google Scholar was also used to identify more recent articles which had cited key literature that had emerged from the initial search. The key words that were used for the initial searches were number, numeracy, maths and mathematics (and math in the USA) combined with anxiety and phobia as these were all terms used within the literature pertaining to anxiety related to number manipulation. When trying to focus the literature search around the specific questions of when, why and how mathematics anxiety develops in some student nurses, it became clear that there was a paucity of specific literature and that which did exist reflected differences of opinion or anecdotal evidence rather than research-based findings. The search was therefore expanded to include more general literature on mathematics anxiety related to settings other than healthcare.

The inclusion criteria for the initial review included all books, journal articles and web resources related to mathematics anxiety that were either peer reviewed or produced by a reputable organisation. The exclusion criteria included material that was anecdotal or based on unsubstantiated opinion. I also initially excluded material related to the pedagogy of mathematics

teaching and the mathematical content of the English National Curriculum, although some of this literature was subsequently included during the analysis stage of the study. The literature was funnelled by reading abstracts and skimming the texts to determine the extent to which it related to the research questions and therefore if it was likely to be of value. It should be noted that some literature originally discarded at this stage was later returned to as new concepts and themes emerged. The majority of the literature reviewed used the term maths. The term chosen for the writing up of this study is mathematics although it is recognised that the skills that student nurses need to demonstrate within their clinical practice are numeracy skills.

The Review

The literature review starts with a definition and discussion of what is meant by the term *mathematics*, followed by a review of the literature on anxiety generally, before the focus narrows to mathematics anxiety, where the discussion has been structured around the research questions. Wider related issues such as the teaching, learning and application of mathematics as well as relevant educational theory are also explored. Finally issues related specifically to mathematics anxiety within healthcare, and particularly nursing, are considered.

What is Mathematics?

There are many terms associated with Mathematics, e.g. Numeracy, Numerosity, Mathematical Literacy, Numerical Literacy and Arithmetic, which are often used interchangeably with the terms Mathematics or *Maths* and

which can therefore cause confusion. Mathematics is defined by the Oxford English Dictionary (2012) as the abstract science of number, quantity and space, studied in its own right (pure mathematics) or as applied to other disciplines such as engineering or physics (applied mathematics). Mathematics is subdivided into topics such as arithmetic, algebra, geometry, trigonometry, integral and differential calculus. GCSE mathematics includes some algebra, geometry and trigonometry, but is not necessarily about ensuring that candidates can add, subtract, multiply and divide numbers. Arithmetic is a subdivision of the field of mathematics that focuses on addition, subtraction, multiplication and division. Numeracy is defined by the National Numeracy Organisation (2013), an independent charity that focuses on adults and children with low levels of numeracy, as the ability to use mathematics in everyday life. This includes significant aspects of what is taught in school mathematics, but also includes the ability to use numbers and solve problems in real life. They go on to argue that many people feel these skills are not adequately learnt in the classroom. Of course the mathematics needed in everyday life will vary considerably between individuals. Many practitioners and researchers see numeracy as a concrete and practical capability, whilst mathematics – in its purest sense – becomes increasingly abstract as children progress through secondary school (National Numeracy Organisation 2013).

The fact that one mathematical term is often used to define another, e.g. numeracy is the ability to use mathematics in everyday life, may go some way to explaining the tendency by many people to use the terms

interchangeably, and of course, there is a degree of overlap. The National Numeracy Organisation (2013) explains that the relationship between mathematics and numeracy is complex and they offer the following diagram to demonstrate the relationship (see Diagram 1):

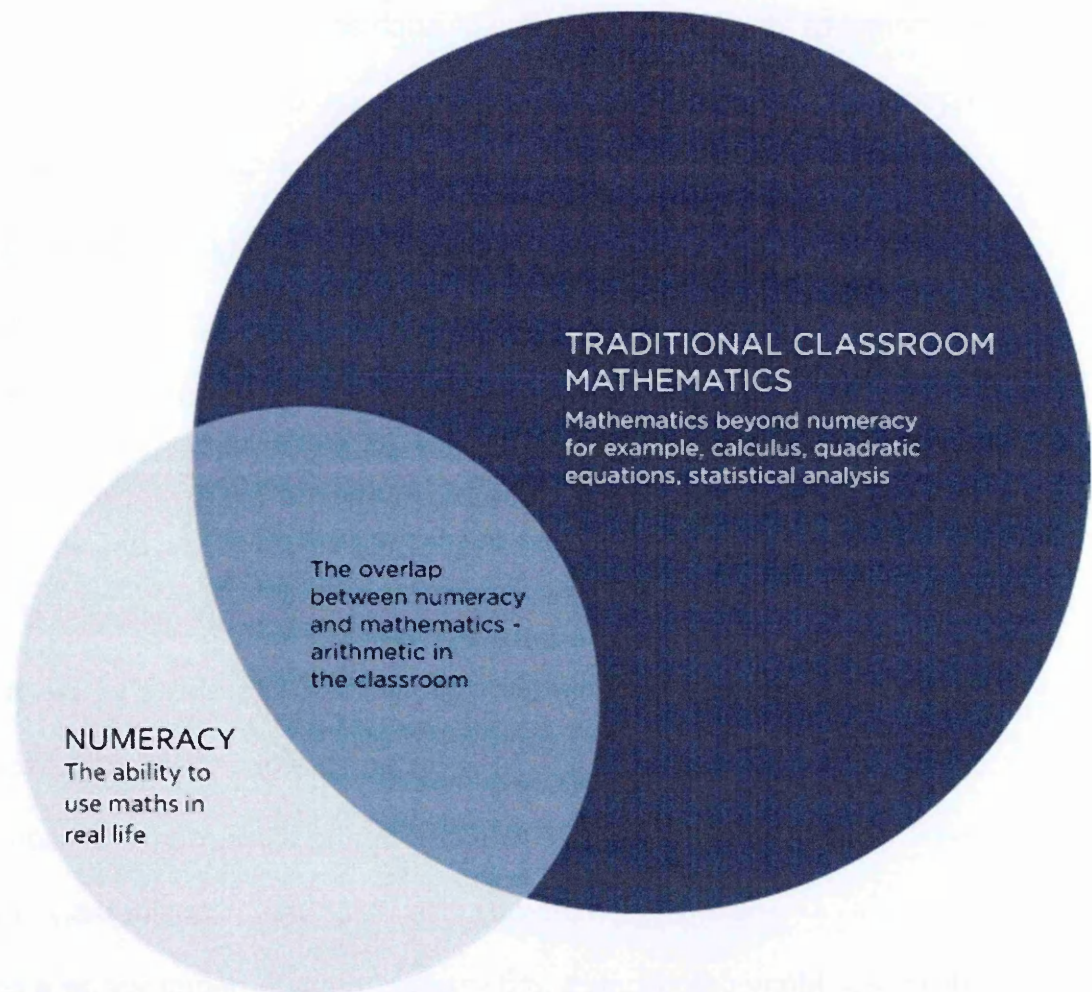


Diagram 1: The relationship between Mathematics, Numeracy and Arithmetic
(National Numeracy Organisation 2013 np) Reproduced with permission.

Whilst this is a somewhat simplistic representation in that the boundaries are rather more blurred than the diagram suggests, it is helpful when thinking about why a GCSE qualification in mathematics does not necessarily ensure that student nurses will have the numeracy skills that they need. In attempting to provide a master-definition for Numeracy, the National

Numeracy Organisation (2013 np) chose the international description of Mathematical Literacy outlined by the Programme for International Student Assessment (PISA) developed by the Organisation for Economic Co-operation and Development (OECD): "Mathematical Literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen". Wright (2011) defines numeracy in a nursing context as knowing what numbers mean and how they relate to each other, as well as the four basic arithmetic functions of addition, subtraction, multiplication and division. Coben (2000) explains that to be numerate means to be competent, confident, and comfortable with one's judgements on whether to use mathematics in a particular situation and if so, what mathematics to use, how to do it, what degree of accuracy is appropriate and what the answer means in relation to the context. This definition is important as it introduces the concepts of confidence and comfort as well as competence related to mathematics.

The lack of distinction between the terms Mathematics, Numeracy and Arithmetic extends to the key contemporary authors in the field. Wright (2007, 2011) uses the terms *maths*, *numeracy* and *arithmetic* when discussing the skills that student nurses need to improve their medication calculating skills, but then argues that nurses in practice are *not doing maths*. (Wright 2011: p xi). She acknowledges that nurses need *numeracy* skills to perform medication calculations but argues that they are performing a nursing skill, not a *maths* skill. Gafford and Phillips (2006) entitle their book

Nursing Calculations but write about the arithmetic of nursing within the text, whereas Starkings and Krause (2013) also use the term calculations in the title of their book but write about numeracy skills within the text. Matheson and Matheson (2000) argue that language is the vehicle of education and that without common language education cannot happen. Therefore the use of clear language that is understood by the learner is an important factor in an effective learning experience.

Philosophies of Mathematics.

There are two opposing philosophies of mathematics, the absolutist philosophy and the fallibilist philosophy, which throughout the latter part of the twentieth century formed the basis of what became known in the USA as the Math Wars (Davison and Mitchell 2008). The disagreement was about the ways in which mathematics should be taught, and the views on the teaching of mathematics were underpinned by these philosophies. The absolutist view is that mathematical knowledge is certain and unchallengeable (Ernest 1991) and that it is a fixed body of knowledge that is ahistorical (Anderton and Wright 2012). Ernest (1991) goes on to argue that the absolutist view of mathematics as objective, logical, timeless and culture free means that for many the subject seems remote and inhuman, very cold and highly technical. Supporters of the absolutist philosophy would promote the teaching of mathematics via fixed step-by-step procedures for solving mathematical problems. Indeed this is the way that mathematics is taught in many UK schools, with teachers asking students to complete repetitive mathematical tasks, often emphasising that the problems must be solved using the appropriate memorised approach (Anderton and Wright 2012).

Anderton and Wright (2012) go on to explain that many students' impressions of mathematics correspond with the absolutist position due to the manner in which they have been taught.

Conversely Ernest (1991) explains that the fallibilist view is that mathematical knowledge is never beyond revision and correction. It has a human side and is corrigible (Anderton and Wright 2012). Mathematics has a history and mathematical knowledge is subject to change. The fallibilist philosophy of education emphasises the human side of mathematics and its relation to real life situations (Ernest 1991). Teaching and learning involves a more inquiry-based approach in which students are exposed to real-world problems that help them develop fluency in number sense, reasoning, and problem-solving skills. Anderton and Wright (2012) point out that some learners do enjoy the absolutist approach, but for others the experience can be so unpleasant that they develop a phobia of mathematics. Allen (2004) claims that the mere thought of mathematics can induce a state of panic in some students. Hewitt (2001) adds that even high achievers can experience mathematics as something to be memorised rather than understood, and Skemp (1976) argues that many learners adopt an instrumentalist approach, believing that success requires the memorising of formulas.

Threlfall (1995) aligned the absolutist philosophy of mathematics with the behaviourist approach to education which is underpinned by a didactic model of transition and a focus on highly structured learned responses. An absolutist approach to teaching focuses on content and student practice and exercises and discourages discussion. Conversely the fallibilist philosophy is aligned with the constructivist approach (Threlfall 1995) which emphasises

self-discovery, focuses on real world examples and problems and encourages discussion. Weeks et al (2001) argue that the fallibilist view that mathematics education emphasises the human side of mathematics, as argued by Ernest (1991), is more appropriate to the ordinary user of mathematics in everyday life because of its relation to real life situations.

Anxiety and its Potential Origins.

Anxiety is a normal phenomenon that within defined parameters and under the right conditions serves as a protective and even a performance enhancing response to potentially stressful situations (Turner 2003). Turner goes on to explain that normal anxiety is the sympathetic nervous arousal that precedes, and is part of, the *fight or flight* response. In other words, it reflects the psychological and physical state required to deal with an emergency and is a normal way of reacting to a number of demanding situations. However, morbid or clinical anxiety is a state where the level of anxiety and the associated physical and psychological effects exceed those required to deal appropriately with the immediate situation.

According to Turner (2003) and Rachman (2004), there are a whole range of factors which could be identified as potential causes of anxiety. Anxiety is often acquired by a process of learning (Rachman 2004) and childhood experiences are a common factor associated with anxiety related to a particular situation. This may also be true for mathematics anxiety, in which case, for some students who experience mathematics anxiety, it might have originated from a past experience, and their subsequent personal interpretation of that experience. Evans et al (2010) also link past experience

and learning, explaining that all knowledge has a context in which it was generated and these contexts include life experiences.

Bandura (1997) argues that a person's perceived coping efficacy is a major contributor to anticipatory anxiety and the more efficacious they are in relation to a particular skill the less anxious they will be. In other words, the more confident they are about their ability the less anxious they will be. Bandura also claims that, while most people suffer some degree of social anxiety, some are plagued by what he refers to as *social evaluation anxieties* where they constantly worry about what others will think of them. He goes on to explain that people who worry about their ability to cope with a particular situation will suffer chronic distress and will spend a lot of energy on defensive forms of behaviour such as avoidance. Even when activities are objectively safe and offer many potential satisfactions such individuals cannot get themselves to do things they find subjectively threatening. Some people will even avoid easily manageable activities for fear of them leading to a more threatening situation (Bandura 1997) which suggests that a person with mathematics anxiety might avoid relatively easy mathematics for fear of it leading to something more complicated.

Confidence

Confidence is defined by the Oxford English Dictionary (2012) as a firm trust in, or a self-reliance on, one's own ability. Race (2010) argues that confidence is the single most important factor in success. Bandura (1997 p37) uses the term self-efficacy which he defines as "a belief about what one can do under different sets of circumstances with whatever skills one

possesses” which is a comparable concept to confidence. Bandura argues that effective personal functioning is not just about knowing what to do and being motivated to do it, but that it also requires self-belief. Likewise self-efficacy is not about the skills that you have, but what you believe you can do with them. Different people with similar skills or even the same person under different circumstances can perform quite differently depending on their personal efficacy or self-belief at the time. In addition, there is a distinct difference between the self-confidence to perform a specific task and an overall confidence in mathematics (Parsons et al 2011). As a result, self-efficacy or self-confidence is an important contributor to performance accomplishments, whatever the underlying skills might be.

Bandura (1997) identifies four key sources of self-efficacy: past achievement, comparison with others, what others tell you and your feelings or physical state. Parsons et al (2011) in a study of engineering students argued that, for the students they studied, past achievement was the most important of these sources. However, to access an engineering programme these students must have held the required mathematics qualifications for entry so demonstrating previous success and yet they were found to have a worrying “lack of self-confidence in their mathematical capability” (Parsons et al 2011 p54). It is often assumed that increasing a person’s mathematics ability or improving their mathematics skills will inevitably increase their confidence in that ability. For example, Parsons et al (2011 p54) argued that, for their students, success in first year mathematics modules “*naturally* increased their self-confidence”. Likewise, mathematics support usually focuses on improving the students’ mathematical skills, based on the premise that this

will lead to an increase in confidence and subsequently a reduction in their mathematics anxiety. A potential problem with this approach is that it ignores the other factors that are critical components of self-confidence.

Mathematics Anxiety

The terms mathematics anxiety, maths anxiety, math anxiety or numeracy anxiety refer to the negative perception that some people have about doing maths. (National Research and Development Centre for Adult Literacy and Numeracy (NRDC) 2009). It is defined as the feelings of tension that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Richardson and Suinn 1972, Tobias 1993).

Within the literature there is a wealth of information and opinion regarding anxiety generally, and how to manage various forms of anxiety (Kennerley 1995, Turner 2003, Rachman 2004) but there appears to be little specific research undertaken into the origins of mathematics anxiety. Ashcraft and Moore (2009: p197) support this perception, arguing that “given the wealth of information about correlates of mathematics anxiety, it is somewhat surprising that little if any research has been reported concerning its onset or possible causes”. Whilst mathematics anxiety is very much a current issue, it is not a new phenomenon. As far back as the 1950s there were reports on emotional difficulties with mathematics (Gough 1954) and numerical anxiety (Dreger and Aitken 1957). Richardson and Suinn (1972) identified widespread mathematics anxiety in the 1960s and developed a *Maths Anxiety Rating Scale (MARS)* as a tool to measure its prevalence and enable it to be more widely explored. Hembree (1990) noted that such anxiety was

prevalent in US college students at the end of the 1980s and the Dearing Report (NCIHE 1997) acknowledged that mathematics was still perceived as problematic for university students in the 1990s, supported by Tariq (2002) who found that 42 – 63% of first year bioscience students in one university encountered difficulty with a diagnostic test of their basic numeracy skills. The Dearing Report (NCIHE 1997) called for Higher Education Institutions (HEIs) to develop strategies that would enable them to deliver numerate graduates. As a result many HEIs and national groups are constantly looking for ways to better support students, e.g. Learn Higher (Learn Higher 2010), MathsHelp (Open University 2012), Sigma Mathematics Support Network (Sigma 2012).

When does Mathematics Anxiety develop?

There is some evidence of research exploring the question of *when* mathematics anxiety develops. Scarpello (2007) claims that *math anxiety* can begin as early as the 4th grade (9-10 years old, USA), but peaks in Middle and High School, although he does not provide any evidence for this claim. Arnold et al (2002) argue that negative attitudes towards mathematics start to develop much earlier, even before Kindergarten (under 5 years old, USA) whereas Geist (2010) argues that it is when children enter formal schooling that problems start to develop. She explains that children start to construct their ideas about mathematics from the first few months of life, but that on entering school the focus shifts from the construction of ideas to “teacher imposed methods of getting the right answer” (Geist 2010: p25). This includes a focus on repetition and speed (timed tests) which Geist argues undermines the child’s natural thinking process. This view is

supported by OFSTED (2009) who state that many schools - particularly secondary - are not teaching mathematics well enough because they place too much emphasis on routine exercises and on *teaching to the test*. While this style of teaching prepares pupils to pass examinations, and gain necessary qualifications, it is less effective in promoting the required understanding to apply mathematics to new situations, solve problems and communicate solutions.

However, it could be argued that repetition is one of the best ways to learn some aspects of mathematics such as times tables and being able to offer the answer quickly and confidently may serve to increase rather than decrease a person's confidence in their mathematics ability. For example, Race (2010) claims that repetition is an important learning tool, arguing that if something is important it should be heard again and again, and that practice and repetition are two of the key factors that help people become good at something. He goes on to say that repetition not only pays dividends in learning performance but can also be an invaluable as part of an intentional learning strategy. It would therefore appear that repetition can be a useful learning tool but that it should form part of a wide repertoire of learning skills. However, when students rely solely on repetition as their only approach to learning, problems can start to occur.

The answer to the question of when mathematics anxiety develops in some student nurses is likely to be *in childhood* for many, but there is clearly no agreement on specifically when during childhood anxiety may originate, or whether it can in fact develop at any age. Geist (2010) has identified the emphasis on "getting the answer right" as being problematic for some

children, and it is likely that this remains true for many adults. Mackenzie (2002) undertook a study of the level of mathematics anxiety amongst the students attending the HE College in which she was working. She asked about the students' enjoyment of mathematics at various stages of schooling. Of 466 respondents, 73% claimed to have enjoyed mathematics at primary school but this had dropped to 48% by secondary school and 25% admitted to some current concern and avoidance of mathematics learning. Mackenzie notes that this figure is consistent with other studies such as those carried out by Betz (1978) and Hembree (1990). However she also claims that this figure is likely to be an under-representation of actual levels of mathematics anxiety based on the assumption that students who are interested in and comfortable with mathematics are those most likely to return the questionnaire (the return rate was 42%). Whilst this could be true, there is absolutely no evidence to support this assumption. One could just as easily argue that those concerned about their mathematics ability are more likely to respond in the hope that responding may precipitate help and support with addressing their concerns.

Who is most at Risk of Mathematics Anxiety?

Mathematics Anxiety appears to be an international problem and has been the focus of much research in the UK and abroad - for example, Hutton (1998a) and Wright (2010) (UK), Scarpello (2007) and Geist (2010) (USA), Kapborg (1994) (Sweden), Krinzinger et al (2009) (Germany), Ader & Erktin (2010) (Turkey) and Kai Kow Joseph (2004) (Singapore).

Geist (2010) claims that those most at risk of mathematics anxiety are females and from low socio-economic groups, although Mackenzie (2002) argues that her study did not indicate that anxiety and low confidence are gender-linked. An OFSTED (2007) report indicated that girls outperform boys in all subjects including Mathematics at Foundation stage, and this continues through to GCSE level (OFSTED 2009). However I can find no studies that have specifically compared achievement at GCSE with levels of mathematics anxiety in the candidates. If the argument that mathematics anxiety and mathematics ability are linked is true then higher achievement rates in girls would suggest that anxiety rates are lower. However, Sabin (2001) maintains that there is a gender difference, and argues that mathematical ability is socially constructed and that women are much more likely to underestimate their mathematics ability and therefore be more prone to mathematics anxiety. This lack of consensus suggests that any links between gender and levels of mathematics anxiety warrants further investigation.

Signs and Symptoms of Mathematics Anxiety

Mathematics anxiety reactions can range from mild to severe, from seemingly minor frustration to overwhelming emotional and physiological disruption (Ashcraft and Moore 2009). People can experience mathematics anxiety in formal settings such as in a classroom or examination situation or in more everyday settings such as shopping or settling the bill in a restaurant. Signs and symptoms include panic, a feeling of helplessness, paralysis and mental disorganisation (Tobias and Weissbrod 1980), and whilst mathematics anxiety directly influences a student's confidence (Tobias and Weissbrod 1980), a lack of confidence is itself considered to be a factor

in further exacerbating mathematics anxiety (Dodd 1999), so it may be that a spiral effect is created in some cases.

Krinzinger et al (2009) identified that mathematics anxiety in children may exert considerable negative effects on their academic and social life, and there is no reason not to presume that this would be equally true of adults. It is widely recognised (Richardson and Woolfolk 1980, Hopko et al 1998, Ashcraft and Moore 2009) that mathematics anxiety, like other types of anxiety and even phobias, influences individuals on three different levels, physiologically, psychologically / cognitively and socially. Physiologically sufferers may experience sweating and rapid heart rate, palpitations and / or nausea. Psychologically they may experience what Richardson and Woolfolk (1980) describe as “worrisome thoughts” and it is these worrisome thoughts, they argue, that are likely to lead to avoidance behaviour. Hopko et al (1998) recognised that worrisome thoughts are hard to inhibit and will therefore absorb working memory and attentional resources. They call this a “deficient inhibition mechanism” (Hopko et al 1988 p.343) and suggest that the poorer calculation abilities of individuals with high mathematics anxiety are not so much a consequence of their worrisome thoughts but are more likely due to an inability to withdraw their attention from these thoughts. This is supported by Ashcraft and Kirk (2001) who found that students with higher levels of mathematics anxiety displayed lower working memory spans for numerical tasks, along with longer reaction times and higher error rates.

Socially, individuals with high mathematics anxiety levels are likely to avoid social situations that require mathematics such as working out their share of

the bill in a restaurant. Ashcraft and Moore (2009) stress that mathematics anxiety is a significant impediment to mathematics achievement and one that affects a considerable portion of the population, and therefore warrants serious attention in terms of both assessment and intervention. They go on to argue that, whilst mathematics anxiety is not a learning disability in any traditional sense of the term, it does function as a disability in that it has negative personal, educational and cognitive consequences, disability being defined under the Equality Act (The Home Office 2010) as a physical or mental impairment which has a substantial and long-term adverse effect on a person's ability to perform normal day to day activities.

How does Mathematics Anxiety Develop?

As previously mentioned, Ashcraft and Moore (2009) have questioned why little if any research has been reported concerning the onset or possible causes of mathematics anxiety. In searching the literature I have been unable to find any evidence of structured investigations into the causes of numeracy or mathematics anxiety, although several authors and experts do express opinions as to the causes. For example, Professor Marcus Du Sautoy from Oxford University, in a BBC Radio 4 debate on Dyscalculia, suggests that mathematics anxiety can be due to "bad teaching in the past" (Du Sautoy 2011). Likewise, Scarpello (2007) suggests that mathematics anxiety might be caused by past classroom experiences, parental influences and remembering poor past mathematics performance, but he does not provide any evidence to support this claim. He goes on to say that teachers need to be aware that students may suffer from mathematics anxiety and that they should employ effective teaching methodologies to lessen anxiety

in their classroom. However, he offers no suggestions as to what these effective teaching methodologies might be. It is of little help to practitioners to advise them to do something if they do not know what it is that they can do.

Krinzinger et al (2009) recognises that, whilst mathematical learning difficulties are often associated with mathematics anxiety, very little is actually known about the causal relations between calculation ability and mathematics anxiety. In an attempt to address this, they undertook a study of 140 primary school children to longitudinally investigate the relationship between calculation ability, self-reported evaluation of mathematics and mathematics anxiety. Whilst their results showed a strong influence of both calculation ability and mathematics anxiety on the students' evaluation of mathematics, they demonstrated no causal effect of mathematics anxiety on calculation ability or vice versa. Krinzinger et al (2009) go on to speculate that frequent poor mathematics performance or failure to understand mathematical concepts might lead to negative emotions such as mathematics anxiety, which in turn is likely to provoke avoidance behaviour.

However, the association between mathematics ability and mathematics anxiety may not be unidirectional in that emotional factors might generally influence cognitive abilities. There is undoubtedly some evidence to support the theory that reducing mathematics anxiety positively influences mathematics performance. A meta-analysis by Hembree (1990) showed that successful treatment of mathematics anxiety in adults led to a significant improvement in their calculation performance, even though their treatment did not involve any mathematics training. A later study by Kamann and Wong

(1994) showed that reducing mathematics anxiety also positively influenced mathematics performance in children with mathematical learning difficulties. This evidence suggests that there is a cyclical problem here with poor mathematical performance causing anxiety, anxiety causing avoidance of mathematical scenarios and this avoidance causing a further reduction in performance ability. It is easy to see how this cycle may develop into a downwards spiral making all three factors progressively worse. In order to devise strategies to address these issues, and attempt to break the cycle it would be helpful to acquire some understanding of the origins of that anxiety.

How Mathematics Anxiety is Measured

The need for a tool to measure mathematics anxiety was identified back in the 1960s by Richard Suinn who was working at Colorado State University and recognised that different types of anxiety lead to different effects on the intellectual performance of the students he was working with. He also acknowledged that mathematics anxiety existed among many individuals who did not ordinarily suffer from any other tensions, and one-third of the students responding to his university's behaviour therapy program indicated that their problem centred on mathematics anxiety (Suinn 1970). As a result he identified that a specific measurement tool was required to provide a measure of the anxiety associated with the single area of the manipulation of numbers and the use of mathematical concepts. This led to the development of the Mathematics Anxiety Rating Scale (MARS) by Richardson & Suinn (1972). The original MARS is a 98 item scale composed of brief descriptions of behavioural situations such as "adding together two three digit numbers while somebody looks over your shoulder" (Richardson and Suinn 1972 p.

552). It is anticipated that such scenarios will arouse different levels of anxiety in different people. Subjects are required to respond with a numerical representation of their perceived anxiety with 1 representing “not at all anxious” and 5 representing “very anxious.” The score is the sum of all the values. This is clearly a very subjective measure on the part of the participant, but anxiety is a subjective experience, and Richardson and Suinn (1972) undertook an intensive study to test and subsequently demonstrate the reliability and validity of the tool.

There does not appear to be any evidence of other independent researchers objectively testing the reliability and validity of the scale, but nonetheless it became a widely accepted measure and has been used in many subsequent studies. However, the large number of items would make it rather complicated and cumbersome to administer to a large group, and there is documented evidence of many researchers seeking a shorter or modified version of the scale, e.g. Suinn and Winston (2003) who developed a shorter 30 item version of the MARS (MARS 30-item). They tested the scale for reliability and validity and were satisfied that the MARS 30-item scale was comparable to the original MARS 98-item scale. Again there is no evidence of independent testing of the reliability and validity of this modified version. There is also a modified version of the MARS designed to better suit adolescents (MARS-A) (Suinn and Edwards 1982) and a 24-item version, the MARS-R which was developed by Plake and Parker (1982).

However, despite the production of these revised versions of the MARS, there have been a number of further tools developed to measure

mathematics anxiety. One such tool is the Abbreviated Maths Anxiety Scale (AMAS) developed by Hopko et al (2003) which is a widely accepted modified version of the original MARS, developed because of the perceived poor fit of the original MARS to large scale studies of undergraduate students. The AMAS is a 9 item scale which is simple to use, and particularly appropriate for larger scale studies.

Mathematics Anxiety and Healthcare

What the literature does suggest is that there is a clear link between mathematics anxiety and performance in numeracy tests (Bull 2009). Gladstone (1995) echoes the concern of many that, within the healthcare professions, a lack of mathematics ability can lead to medication calculation errors in practice, although Wright (2010) in a review of the literature on medication errors challenges this assumption, arguing that she found insufficient evidence to suggest that medication errors are caused by nurses' poor calculation skills. Nonetheless, if nurses are required to calculate medication doses for their patients, then sound calculation skills, and well-placed confidence in those skills must increase the chances of accurate doses being administered and will therefore contribute to improved patient safety.

Young et al (2013) claim that registered nurses can spend up to 40% of their professional clinical practice involved in medication dosage calculations and associated problem solving activities. They stress that there is an essential relationship between numeracy and medicines management and argue that numeric skills must be mastered to ensure safe dosage calculation. Arnold

(1998) found that the vast number of mistakes that nurses made in mathematics assessments were conceptual in nature, in that they failed to set up the problem properly. In other words, when presented with a medication calculation problem they were unable to extract the appropriate information to perform the calculation required. Arnold (1998: p.22) claims that "there was nothing wrong with their arithmetic skills", so suggesting that their underlying mathematical ability was sound but that something was prohibiting them from using their skills appropriately. For some students this may be their level of anxiety related to mathematics. Such students need more than good teaching strategies and, in some cases where anxiety is deep-seated; the support required is tantamount to counselling. However, prevention is better than cure and yet there does not appear to be any available research focussed on exploring the origins of mathematics anxiety and whether strategies can be developed that avoid such anxiety being created in the first place, or at least to neutralise it in the early stages of further study. It is often suggested that bad experiences and poor or inappropriate teaching strategies are to blame, but these claims are mainly based on anecdotal evidence. Mathematics anxiety is widespread, so it is likely that there are many factors which have an impact and that these will vary from one individual to another.

Nurse Education

The Nursing and Midwifery Council (NMC 2010) has produced standards for pre-registration nursing education with which all institutions offering nurse education programmes must comply. This is to ensure that on completion of their pre-registration programme, all student nurses have achieved the

competencies required to enter the register as a qualified nurse. The ultimate aim of these standards is to safeguard the public.

The generic standard of competence the NMC requires is that by the point of registration all nurses must be able to work autonomously and that they must practise with confidence. In order to achieve this competence in practice, 50% of the entire pre-registration nursing programme consists of placements in the practice setting. As part of the standards for pre-registration nursing education the NMC (2010) have clearly outlined a number of competencies that are required of a registered nurse. Competencies are defined as “the combination of skills, knowledge and attitudes, values and technical abilities that underpin safe and effective nursing practice and interventions” (NMC 2010 p11).

In order to clarify some of the specific skills required the NMC have also identified five Essential Skills Clusters (ESCs), one of which is Medicines Management. Medicines management is defined as “the clinical cost effective and safe use of medicines to ensure patients get maximum benefits from the medicines they need whilst at the same time minimising potential harm” (NMC 2010 p.134). The NMC specifically states that registered nurses must be able to correctly and safely undertake medicine calculations (p134) and administer medicines safely in a timely manner (p.139). ESCs are sets of skills that it is considered essential for a qualified nurse to possess. Whilst these are generally skills that must be achieved by the point of registration, the NMC does determine specific levels of skill that must be achieved by each progression point of the programme. For example, in relation to

medicines management, by the first progression point (the end of the first year) students must demonstrate “competence in basic medicine calculations relating to tablets and capsules, liquid medicines and injections” (NMC 2010 p134). Coben et al (2010 np) define medication calculation competence as the undertaking of “appropriate arithmetical operations and computations to calculate a numerical value that falls within an appropriate degree of accuracy for the required dose or rate”.

The NMC (2010) also offers guidance related to the numerical assessments that must form part of the pre-registration nursing programme. They require education providers to incorporate health related numerical assessments, designed to test numeracy skills, into learning outcomes and assessment strategies. They specify that the focus should be on the demonstration of competence and confidence with regard to whether to use a calculation, what calculation to use and the degree of accuracy required as well as an understanding of what the answer means in relation to the context. Whilst the education provider can determine their own pass marks for progression points 1 and 2, at progression point 3 (point of registration) the pass mark must be 100%.

Axe (2011) argues that students express anxiety because they are fearful of a requirement of 100% in an assessment. She was referring specifically to students on nurse prescribing programmes but pre-registration students are also required to achieve a pass mark of 100% at the point of registration. Therefore it is likely that they will also be fearful of this requirement and this will inevitably exacerbate any existing anxieties. In addition, pre-registration

students must be assessed in the practice setting throughout their programme of study, and in the practice setting the required pass mark is always 100%.

Whilst the NMC provides guidance on the required pass marks for assessment, it does not offer any guidance as to the content of these assessments or any benchmarks related to the degree of difficulty of the calculations that must be performed. Coben et al (2010) report that there have been calls for benchmarks on requirements for entry to pre-registration programmes to be devised and for there to be some absolute measure of achievement and performance at the point of registration, but despite the completion of a research report for NHS Education for Scotland, advocating the use of such benchmarks (Coben et al 2010) they have still not been introduced. So for the time being institutions must set their own assessments, inevitably leading to differences in expectations across the country. Hutton et al (2010) add that as well as no national agreement, there is no international agreement on exactly what number skills are needed for nurses at the point of qualification, or how they should be developed and assessed.

Mathematics Anxiety and its Implications for Healthcare Programmes

Hembree (1990) noted that “otherwise capable” students were avoiding the study of mathematics and making subsequent career choices accordingly. Mackenzie (2002) noted from her study that students studying English reported the highest level of avoidance of mathematics (40%), and it seems logical to surmise that these students might have chosen their course,

assuming that mathematical skills would not be required. However she also noted avoidance levels of 33% amongst applied social science students, who in many cases may need to do mathematics as part of their programme of study, and within their subsequent practice, but they may not have realised this when applying. Most healthcare programmes, especially nursing programmes, require a mathematics qualification equivalent to a GCSE grade C or above as part of the minimum entry criteria, although it is recognised that a GCSE Mathematics covers a broad curriculum and is not necessarily a good indicator of arithmetic or numeracy skills.

Many students assume that a mathematics GCSE is just a standard entry requirement and do not associate this requirement with an expectation that they will need to use mathematics within their programme of study or within their field of work. This is supported by the report of the Higher Education Academy's SUMS (Students Upgrading Maths Skills) Project (Carter et al 2010) which states that difficulties with mathematics are likely to be over-represented in students with low mathematics skills who mistakenly opt for subjects which they expect to have no mathematics requirements. The HEA report goes on to say that there is often a mismatch between the capabilities and expectations of students on the one hand and the demands of their programme of study and more generic requirements on the other.

One significant problem for nurses is that they need sound numeracy skills in order to accurately calculate medication for their patients as well as perform other duties in practice. Hutton (1998b) has developed a taxonomy of the essential numeracy skills that are required by nurses. These include the

ability to add, subtract, multiply and divide. For students who are not able to demonstrate these skills, not only do they need to learn, or re-learn, them in university, but they need to be able to transfer them to the clinical areas in which they will be working. Eraut (2004a) explains that performance in the workplace typically involves the integration of several different forms of knowledge and skill, a process which he calls knowledge transfer. He defines knowledge transfer as when a person learns to use previously acquired knowledge, skills or competence in a new situation, so a student nurse learning to use their mathematics skills to perform medicine dose calculations in a clinical setting would be a good example of this. Eraut (2004a) goes on to say that this transfer of formal knowledge to practice settings requires both understanding and positive commitment from individual learners as well as from their educators, employers and workplace managers. If an individual lacks confidence in their skills, this is likely to impact on their positive commitment, and therefore their ability to transfer, yet mathematics skills are generally considered transferable skills.

University-based educators tend to focus on the acquisition of mathematics and medication calculation skills rather than any additional learning required to facilitate their transfer. Although students are taught applications such as medicine dose calculations by university staff, their actual practice in the clinical setting is supported and assessed by clinical staff in that area, and there may be little direct or regular communication between the two.

According to Grove (2012), many academics believe that current mathematics provision at school leads to students learning by rote rather

than through their own independent techniques. This is worrying considering that Eraut (2004a) claims that the transfer process may entail considerably more learning than the original acquisition of knowledge. Evans et al (2010) challenge this concept of knowledge transfer, arguing that, as opposed to being transferred, knowledge is contextualised and recontextualised in movements between different sites of learning, and that it is this recontextualisation that is the basis of one of longstanding challenges of integrating subject-based and work-based knowledge. In order to facilitate recontextualisation there is a need to understand how knowledge is changed as it is put to work (Taylor et al 2010).

Educational Theory

Eraut (2004a), like many other authors (e.g. Carper 1978, Evans et al 2010), argues that there are different types of knowledge. He explains that one type of knowledge is cultural knowledge which is that which is influenced by the context and setting in which it occurs. There is also personal knowledge which is that which individuals bring to situations that enables them to think, interact and perform. Eraut argues that personal knowledge is influenced by events and emotions, and includes aspects of a person's knowledge that have been constructed through lifelong learning experiences. Therefore negative life experiences that individuals associate with a specific area of learning are likely to impact on their ability to transfer that knowledge (Eraut 2004a) or to recontextualise it (Evans et al 2010) into a different site of learning such as clinical practice.

Grove (2012) argues that there is a well-documented problem with the mathematical preparedness and skills of undergraduate students as they make the transition to university study, which he defines as the maths problem. Grove refers specifically to physics and engineering students, but experience suggests that this is also true of healthcare students. Parsons et al (2011) also undertook a study of engineering students and found that, despite having the entry qualifications for their programme many students lacked the required mathematical skills. They also noted that a related problem was the students' lack of self-confidence in their mathematical ability. It is evident that this problem applies to other disciplines as well. Grove (2012) goes on to argue that there are now three aspects to this maths problem, namely a lack of core mathematical knowledge and concepts, a lack of fluency in applying mathematics, specifically an inability to solve unfamiliar problems and insufficient study of mathematics prior to university entry particularly in disciplines outside of engineering, mathematics and physics. He does not identify mathematics anxiety or a lack of self-confidence related to mathematics as being part of the problem.

Eraut (2004b) stresses that most work-place based learning occurs on the job, rather than in formal educational settings and yet in healthcare the expectation is that professionally-based mathematics skills will be taught in university, which provides an artificial context for the clinical applications that are required in practice. This is supported by Taylor et al (2010) who argue that what has been learned in one training context such as the classroom is sometimes difficult to recall and use in another context such as the workplace. Hutton (1998a) suggests that the solution to this is to teach and

test nursing mathematics in real situations as, in her study, student nurses were particularly poor at solving paper-based written problems. Hutton et al (2010) argue that making numbers real and encouraging practice in authentic situations removes much of the fear and perceived difficulty that student nurses associate with mathematics. Perhaps this could be achieved to some extent by creating more realistic learning and assessment experiences such as simulations and Observed Structured Clinical Examinations (OSCEs), although the logistics of providing these for large cohorts of students (500+) are problematic. This is supported by Hutton et al (2010) who also argue that an OSCE designed to cover a good range of medication calculations for a large cohort of student nurses would be impractical in terms of assessor time and at risk of problems such as assessor fatigue and student stress.

An alternative suggested by Hutton et al (2010) is a realistic computer programme, such as that developed by Weeks et al (2001) which is able to simulate real life scenarios and test students in a safe environment. A study carried out by Hutton et al (2010) showed a reasonable correlation between the results achieved via an OSCE and those achieved with this on-line assessment tool.

Schutz (1967) describes how any individual is embedded in a continuous flow of experience, but discrete experiences or episodes will stand out and become meaningful. Eraut (2004b) adds that, if we consider that most of these episodes occur within social contexts, it becomes clear that other social factors may influence what is remembered and therefore what is learnt. An individual's level of mathematical skills can not only affect their

own confidence but also their ability to engage in some forms of employment, and even social activity. It may also affect how they are perceived by others.

The way in which individuals perceive themselves and are perceived by others can be linked to the concept of Capital, as identified by Bourdieu (1986) and which he describes as one of three thinking tools. These three thinking tools are Capital, Field and Habitus and they can be used to help understand social interactions. Bourdieu (1986) defines Capital as the accumulated labour which when appropriated on a private basis by agents or groups of agents enables them to appropriate social energy in the form of reified or living labour. Capital acts as a social relation within a system of exchange. In other words, Capital is the valued resource that an individual might possess which gives them an actual or perceived advantage in society. Therefore mathematics skills could be considered as a form of Capital. Individuals can activate the Capital they possess to achieve personal interests in accordance with the dominant practice in a specific social setting (the Field), which is also influenced by their personal dispositions (the Habitus) which are produced by their prior life experiences (Wang 2008).

Bourdieu (1986) goes on to define three forms of capital: Economic, Cultural and Social. "Cultural capital refers to both knowing that and knowing how" (Matheson and Matheson 2000 p9) and is the non-financial social assets that promote social mobility beyond economic means. Education is a form of cultural capital, with educational qualifications representing cultural capital in what Bourdieu describes as the institutionalised state. Cultural capital exists in 3 forms: the embodied state (long-lasting dispositions of mind and body,

for example, knowing how to address teachers), the objectified state (cultural goods – pictures, books, instruments, machines) and the institutionalised state (qualifications etc.). Each can be converted to another to some extent. Education is a form of cultural capital which takes time and effort to accumulate and that effort has to be on the part of the individual. Cultural capital in the embodied state requires the investment of time; it cannot be delegated or done second hand. In other words it cannot be directly passed from one individual to another. However, domestic transition of cultural capital is possible through, for example, investment in education. Therefore a child from a family where education is valued is more likely to gain educational qualifications and so possess cultural capital.

Eraut (2000) emphasises his argument that the process by which knowledge is acquired is affected by the learning context, and that subsequent use of that knowledge in a different context will require further learning, so it can be seen that an individual's ability to recontextualise their knowledge could both affect and be affected by the degree of cultural capital that they possess.

According to Matheson and Matheson (2000) when the cultural capital of one group does not coincide with that of another, a space appears. This space can be termed cultural distance. The cultural distance that exists between a student and their teacher will inevitably impact on their relationship and the learning that takes place. According to Di Maggio (1982) teachers communicate more easily with students who participate in elite status culture, give them more attention and special assistance, and perceive them as more talented or gifted than students who lack cultural capital. This attention and special assistance is important as, according to Noddings (2003), teaching is

relational and students learn best from teachers with whom they work closely, and it matters to students whether or not they like or are liked by their teachers. If Di Maggio's argument is true, students who possess the appropriate cultural capital are likely to experience less cultural distance between them and their teacher and are more likely to have a better relationship with them, thereby learning more, acquiring more knowledge, better qualifications and subsequently more cultural capital. Conversely those who lack the appropriate cultural capital are less likely to establish good relationships with their teachers and may experience greater cultural distance between them. They will therefore struggle to learn, but receive less help, making it more difficult to raise their status, and potentially causing them to disengage.

Matheson (2006) explains that cultural distance is about whether something is for the likes of me, and she introduces the concept of optimal cultural distance. This is the point at which education becomes for oneself rather than not for oneself. She goes on to argue that some learners, particularly those from lower socio-economic groups, experienced a mismatch between their social identity and their academic identity and sometimes the two were incompatible. Matheson (2006) argues that many students from lower socio-economic groups did not consider themselves to be the type of person to be a university student and experience suggests this is certainly true for some student nurses. The problem for some students is that they feel like outsiders in Higher Education, which in itself is likely to affect the extent to which they engage.

Noddings (2003) argues that teaching is much more than a means and that the relationship between the teacher and learner is central to successful learning. She does acknowledge that in the context of the teaching learning relationship, teaching is means orientated, but argues that what is needed in order to be able to learn differs from student to student, and that individual students need different preparation depending on what they want to do with their knowledge. This fits with Evans et al's (2010) theory that contextualisation and subsequent recontextualisation of knowledge is the basis of one of the longstanding challenges for both teachers and learners. Mortiboys (2012) also argues that, in further and higher education, learners are less likely to drop out from courses if they have a better relationship with teachers. He goes on to argue that better relationships are developed as a result of teachers teaching with Emotional Intelligence.

Mortiboys (2012) defines Emotional Intelligence as the knowledge of what it is that the teacher needs to have and to develop in order to maximise the potential for emotions to support rather than hinder learning. Mathematics anxiety could be considered an emotion that hinders the learning of mathematics, so recognising that anxiety and working with it is important. The learners' emotions have an effect on their learning and the teacher has a significant role in shaping those emotions. Whilst there are influences on the learners' feelings that the teacher cannot control, there are things within their control that can affect how the learner feels, and therefore how much they learn. The amount that a student will learn is also affected by the approach they take to that learning.

Learning can take place on several different levels. Bloom's taxonomy of educational objectives (Bloom et al 1956) is a hierarchical representation of the thinking skills associated with different levels of learning. It is generally suggested that one moves up through the levels as the learning related to a particular topic increases (see Fig.1). Knowledge is considered to be the lowest level thinking skill within this hierarchy.

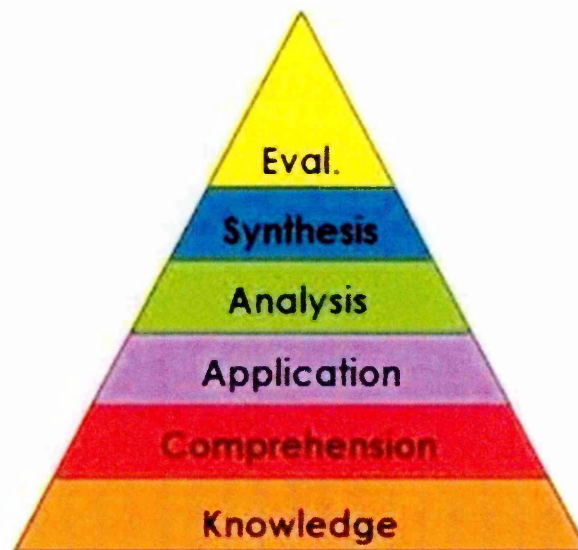


Fig. 1: Bloom's Taxonomy of Educational Objectives (Bloom et al 1956)

Blooms taxonomy is a well-established educational tool, used to help design programmes of study and develop learning objectives. The original 1956 taxonomy has subsequently been revised (Anderson and Krathwohl 2001) and now refers to the level of thinking skills rather than educational objectives (see Fig.2)

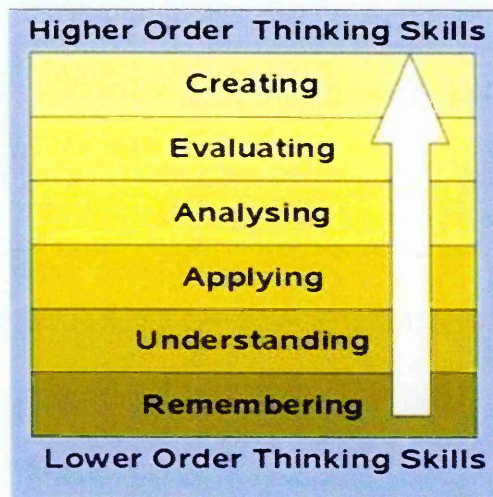


Fig. 2: Revised Bloom's Taxonomy (Anderson and Krathwohl 2001)

When students are uncomfortable with a subject such as mathematics, they may not move beyond the level of knowledge or remembering. Webb (1997) explains that some students do not see past the text to the sense and meaning of the subject they are studying, but they would simply try and remember the text. In other words they are employing a surface approach to that learning rather than a deep approach. Whilst the learning of mathematics does not involve *text* in quite the same way as other subjects, it can easily be seen how this principles of deep or surface learning would still apply. Webb (1997) defines a *deep* approach to learning as one in which a person tries to understand and construct meaning from a learning event. In other words, they try to develop the higher level thinking skills outlined by Anderson and Krathwohl (2001). Deep learning is generally considered to be *learning with understanding* as opposed to surface learning which can be aligned with rote learning.

Beattie et al (1997) argued that whilst the distinction between surface and deep learning is somewhat oversimplified, the concepts are helpful in understanding some aspects of learning. They argue that it is unrealistic to

assume that a deep learning approach is always desirable and that sometimes it is necessary, dependant on the nature of the knowledge to adopt a surface approach. In addition, the type of learning that will be achieved is determined partly by the student's personality, motivation and study methods and partly by the learning task, and the attitudes and enthusiasms of the teacher. Race (2010) defines strategic learning as deliberate surface learning, and may be regarded as *learning for the exam*. This suggests that the learner is making an informed choice about when to be a surface learner and when to be a deep learner. Race goes on to claim that most learning done by most people in post-compulsory education is actually only surface learning, and that when it has served its purpose (i.e. when the examination is passed) it is ditched.

Donnison and Penn-Edwards (2012) argue that during the first year of study the use of assessment as a motivator for surface learning is a valid pedagogy and forms a critical initial stage in the students' development towards lifelong learning. They argue that, whilst surface approaches to learning are generally considered to be ineffective, some surface approaches such as memorisation do have a place in the learning of some subjects such as mathematics. Race (2010) argues that strategic learners i.e. those who deliberately engage in a surface learning approach with a focus on what is needed to gain marks in an assessment, tend to be at least moderately successful, although Burton et al (2009) found that surface approaches to learning do correlate with lower grade averages over the first semester of study. Biggs and Tang (2007) describe such a strategic approach to studying as an *achieving approach* which is about putting effort into organised

studying with the intention of fulfilling assessment requirements, but is not necessarily about gaining understanding or developing transferable skills.

Lave (1988) discusses the concept of Situational Learning, based on the idea that much of what we learn is specific to the situation in which we learn it. This is particularly relevant to mathematics education, as the concept emphasises the mismatch between typical school teaching of mathematics and the real world situations where mathematical knowledge needs to be deployed (Anderson et al 1996). Lave (1988) claims that arithmetic practices are made to fit the activity at hand and do not transfer from school to everyday situations or vice-versa, because there are discontinuities between the techniques used in school and those used for real world situations such as shopping, selling, cooking and making clothes. However, Anderson et al (1996) challenge this argument claiming that it does not follow that arithmetic procedures taught in the classroom cannot be used by a shopper or street vendor. They propose that what is needed is a greater balance in teaching between the generality of the subject and enough situational context for its application.

Mathematics in the Practice Environment

There have been several studies which identify that many student nurses have difficulties with accurately calculating medication doses in practice due to their underpinning numeracy skills (Hutton 1998a, O'Shea 1999, Wilson 2003, Wright 2007), and these difficulties can ultimately lead to errors. Medication errors are defined by Wolf (1989) as mistakes associated with medications, medicines or drugs that are made during the prescription,

transcription, dispensing and administration phases of preparation and distribution.

O'Shea (1999) stresses that medication errors are a multidisciplinary problem but she acknowledges that whilst medicines are prescribed by the doctor and dispensed by the pharmacist, the responsibility for correct administration often rests with the nurse. In other clinical settings the responsibility may rest with other healthcare practitioners such as paramedics or operating department practitioners.

Of course it is increasingly the case that now, a decade later, nurses and other non-medical prescribers are also responsible for prescribing as well as administering medications, and although prescribing is an extended role for qualified nurses, there is still evidence of mathematics anxiety amongst post-registration students taking the non-medical prescribing course. Weeks (2000) points out that with this extended role and the increases in technology and the range of medications available, the numeracy skills required by nurses are becoming even more complex and critical. Warburton and Khan (2007) add that with the expansion of nurse prescribing to include the whole British National Formulary, including controlled medications such as opiates, it is essential that all prescribing nurses can accurately calculate and check medication doses. However, *all* nurses need to be able to accurately calculate and check medication doses, not just those with prescribing responsibilities, because errors can occur at any stage of the prescribing and administering process (O'Shea 1999).

So whilst it is essential for prescribers to prescribe accurately, it is equally important that those interpreting the prescription and administering the medication are accurate in their calculations and have the knowledge, skill and confidence to recognise an inappropriate prescription or dose.

A report from the National Patient Safety Agency (NPSA 2009) reported that there has been a significant year-on-year increase in the reporting of medication incidents from England and Wales to the National Reporting and Learning Service (NRLS) with 86085 incidents reported in 2007. It is highly possible that this is only the *tip of the iceberg* and that in addition to these incidents there are many more which go unreported. The report goes on to say that medication errors were the third largest category (9%) of incidents reported to the NRLS with only *patient accidents* and *treatment/procedure incidents* scoring higher reporting statistics. Whilst 96% of the medication error incidents reported during 2007 had associated clinical outcomes of no harm or low harm, the NPSA received 100 medication incident reports of death and severe harm during the same year. Of these 41% were due to errors in medicine administration with a further 32% due to prescribing errors. *Wrong dose* was amongst the most frequently reported incident types within these categories. This reflects the earlier 2004 report from the Department of Health which states that 25% of all litigation cases against the NHS were reportedly related to errors in medication administration (Department of Health 2004).

Mathematics is required in many other aspects of healthcare work, not just the calculation of medication doses, and all healthcare professionals need to

use numeracy skills accurately within their practice. Eraut (2004a) stresses the overwhelming importance of confidence as a factor affecting learning in the workplace, so mathematics anxiety is a potential problem for all healthcare students and practitioners. O'Shea (1999) does emphasise that numerical ability is only one of a number of factors that can increase the likelihood of medication errors occurring in practice with other factors such as workload, shift patterns and staffing levels also having a significant impact, but a number of studies have identified that medication errors resulting from the poor numerical skills of nurses is a perpetual problem.

Bayne and Bindler (1988) identify mathematical proficiency as a prerequisite to the performance of many nursing functions such as medication calculation, but undertook a study which indicated that a substantial number of student nurses did not possess the basic mathematical skills necessary to function as registered nurses. More worryingly subsequent studies such as those by Warburton and Khan (2007) have shown that many registered practitioners also have inadequate skills. Bayne and Bindler's (1988) study suggested that the years of experience and educational background of registered nurses appeared to make no difference to the incidence of medication errors made by them, suggesting that the problem does not decrease with experience. However, Perlestein et al (1979) found that experienced nurses were more certain in their judgement, i.e. were confident that they were right, even when they were wrong. This is supported by Ashcraft and Faust (1994) who identified that adults exhibiting high mathematics anxiety suggested solutions to calculation problems faster, but less accurately than individuals without mathematics anxiety. For

practitioners in a clinical setting this could have potentially disastrous results. It must be noted that Wright (2010) in a review of the literature on medication errors claims that there is insufficient evidence to suggest that medication errors are caused by nurses' poor calculation skills, but even if this is true, it would be negligent to ignore the problem.

Ashcraft and Moore (2009) identify that mathematics anxiety causes a decline in performance when mathematics is performed under timed, high stakes conditions, which they refer to as an "affective drop". This is significant for two reasons – firstly, as the authors advocate, this suggests that mathematics tests such as those which student nurses are required to pass will provide an under-estimate of true ability. Therefore students may be failing assessments inappropriately. Secondly, and more importantly, this suggests that individuals with mathematics anxiety tend not to perform well in stressful situations. In the practice environment, nurses and other healthcare practitioners often find themselves in stressful *emergency* situations where they need to function quickly and effectively, sometimes against a somewhat chaotic background of shouted instructions, urgent demands and even a sense of panic. A decline in performance during such an event could have life-threatening and even fatal consequences.

Strategies to Help Students Overcome Mathematics Anxiety

There have been many studies investigating strategies to improve the mathematical skills of student nurses (Hutton 1998a, Wright 2007, Curtain-Phillips 2010) but many of the strategies tested were unable to achieve a 100% pass mark for more than a small number of students. A study by

Macdonald et al (2013) exploring the use of a computer based virtual learning environment and assessment package did demonstrate successful achievement of 100% pass mark by all 210 students that took part. However, some students required a number of attempts to achieve this 100% pass mark. Whilst this is acceptable in a university-based assessment, in clinical practice, nurses must always achieve 100% accuracy in medication calculation. Most of the studies that have been undertaken focus on teaching and learning strategies related to mathematics and its application rather than the students' emotional response to the subject, or their level of mathematics anxiety. Therefore a study that explores the issue of mathematics anxiety amongst student nurses may help to further develop learning and teaching strategies, or at least the way in which these strategies are implemented and supported.

Conclusion

The literature review has shown that there is a gap in the literature related to the origins of mathematics anxiety that needs to be examined. It is not clear why such a gap exists and there is little in the literature to offer clues or suggestions. It might be that the complexity of the issues makes it a difficult area to research, but I am not persuaded that this is the case. Inevitably there would be at least a few willing to tackle the issue, however complex, and there would be some evidence of attempted studies if it were so. Networking with support tutors in similar roles at other institutions and discussions around this topic suggest that the reason might be two-fold; firstly that those working with students struggling with mathematics anxiety need to focus on developing and implementing strategies to develop their

students' numeracy skills, and are more concerned with doing something about it rather than investigating why it happened.

The second reason might be that those interested in students with mathematics anxiety feel that they have no influence over the possible causative factors. For example, if it were shown that bad teaching experiences in primary schools were one of the causes of mathematics anxiety in student nurses, what can an academic in a faculty of health do to influence primary school teachers? This view is supported by a project report of the Higher Education Academy (Carter et al 2010 p29) which reports that several delegates who attended the SUMS consultation meetings felt that the problem (of poor numeracy skills in students accessing FE and HE) needs to be "pushed back to school level". They also felt that addressing numeracy problems at HE and FE level is insufficient and that the way the subject is taught at school level needs to be re-examined.

However, it is also possible that, for those involved in teaching mathematics in schools, the problems people have later in life are not a prime concern when they have National Curriculum requirements and class management issues to deal with on a daily basis. It may simply be that this is a subject area that falls between areas of professional practice and simply slips through the net. In order to address this gap, any findings resulting from an investigative study into this area would be disseminated as widely as possible in the hope that they would generate further interest and research. Eraut (2004a p268) stresses the importance of sensitising practitioners and other researchers to the possible factors that influence their work and the

kinds of effects they have, whilst also “warning them that they need to collect good evidence from their own context before drawing any firm conclusions”.

Some of the literature suggests that reducing mathematics anxiety leads to an improvement in mathematics performance, even though no additional mathematics tuition is given (Hembree 1990). This certainly fits with my own experience of students within the faculty of health, where I have noticed that some students with apparently high levels of anxiety say they cannot do mathematics, but can then solve a problem using mathematical principles when the problem is not framed as such. This has led me to suspect that for some students with mathematics anxiety, they genuinely believe they cannot do mathematics when in fact their mathematics skills are better than they believe them to be. If this is true, we do need to address the anxiety and improve the student’s confidence as well as improving their competence in their numeracy skills.

There is also some evidence to suggest that the emphasis on getting the answer right might be contributing to the anxiety students experience related to mathematics (Geist 2010). However, it is self-evident that healthcare professionals, and especially student nurses, must get the answer right every time, because the consequences of not doing so are potentially catastrophic. Within an education setting such as a university, students’ abilities are often assessed by timed tests, and it is a constant topic of debate as to whether anything less than 100% pass mark is acceptable for student nurses. Given the potential implications of getting a medication calculation wrong in practice anything less than 100% is not acceptable, but this does mean that

healthcare courses are reinforcing the undermining focus claimed by Geist (2010). However, by this stage students are adults and should theoretically be able to adapt their learning strategies if they have sound foundations on which to build, and appropriate support in place. Whilst there is a lack of empirical research related to the causes of mathematics anxiety generally, there has been much discussion and debate. However, in the absence of any clear strategies to prevent or cure the problem, further investigation is warranted to generate new insights. Therefore the key area for further exploration was the causes of mathematics anxiety, and the research questions that were to be addressed by this study were:-

- When, why and how does mathematics anxiety develop in some student nurses?
- What can be done to prevent, counteract or overcome this anxiety in order to improve student nurses' confidence in their numeracy skills?

It is anticipated that some improved understanding of the answers to these questions will aid the development of strategies to help student nurses overcome mathematics anxiety, and therefore improve their mathematical ability and their confidence in that ability.

Chapter 3: Research Design and Methodology

This chapter is an account of the design of the study and the methodology.

The key research questions are

1. When, why and how does mathematics anxiety develop in some student nurses?
2. What can be done to prevent, counteract or overcome this anxiety in order to improve student nurses' confidence in their numeracy skills?

The review of the literature has shown that these questions remain largely unanswered (Ashcraft and Moore 2009) and there does appear to be a gap in the literature regarding this focus, so the *origins* of mathematics anxiety is an area that warrants investigation.

The Design of the Study

When deciding how to design the study, I needed to reflect on my epistemological and ontological position. My epistemological position is that of a constructivist in that I believe that knowledge is constructed by the individual and is therefore subjective. Ontologically I hold the post-modernist view that reality is fluid and subject to people's perceptions. I therefore wanted to take a pragmatic approach to the study design. Having established my research questions I needed to determine the methods I would employ , but I had no pre-conceptions about the methods I would use and for me it was important that the research questions determined the methodology rather than vice versa. Robson (2011) argues that a pragmatist would

advocate using whatever philosophical or methodological approach works best for the particular research question, so this is what I did. Whilst my interest was primarily in the experiences of the students related to their mathematics anxiety, I did feel that it was important to ascertain the extent of mathematics anxiety amongst the student cohort. My perception was that there was a high level but I recognised that working in a support department may mean that my perception was skewed. I therefore felt that a survey of a whole cohort of student nurses would produce quantitative data related to the extent and levels of mathematics anxiety within the cohort.

Gray (2004) explains that combining methods such as interviews and surveys enables methodological triangulation. This can help to balance out the weaknesses of single data collection methods, and provide a context for the findings. Therefore an initial survey would provide some context for a later qualitative stage which involved exploring the experiences of some of the students who reported high levels of mathematics anxiety. So, I decided to adopt a Mixed Methods approach or what Robson (2011) determines as a multi-strategy design.

Robson (2011) outlines the characteristics of a multi-strategy design as:

- quantitative and qualitative methods within the same research project;
- a research design that clearly specifies the sequencing and priority that is given to the quantitative and qualitative elements of data collection and analysis;

- an explicit account of the ways in which both types of data relate to each other;
- pragmatism as the philosophical underpinning for the research

Creswell (2003) has determined a typology of multi-strategy designs based on the sequencing and status of the data collection methods. According to this typology this study employed a Sequential Exploratory Design (Creswell 2003). This type of design is characterised by an initial phase of quantitative data collection and analysis followed by a qualitative phase of data collection and analysis. Priority is given to the qualitative phase of the study with both quantitative and qualitative data being integrated within the findings and discussion stage. Creswell adds that the primary focus of this design is to explore a phenomenon which was exactly what I was intending to do.

Bryman (2006) argues that using a mixed methods design and corroborating the quantitative and qualitative data provides triangulation which enhances the validity of the findings. Gray (2004) also explains that combining methods can help to balance out the weaknesses of single data collection methods. Bryman (2006) goes on to say that combining research approaches in this way produces a more complete and comprehensive picture of the topic of the research than might be gained using a single method.

Initially I felt that the underpinning philosophy of the study might be Phenomenology, which focuses on the subjective experience of the individuals studied (Robson 2002). A phenomenological approach considers the whole person and values their experience (Balls 2009), which would be appropriate to the type of data sought.

Phenomenology is traditionally divided into two types, Descriptive and Interpretative. Descriptive Phenomenology was first conceived by the German philosopher Husserl at the beginning of the 20th century (Parahoo 2006) and requires the researcher to aim to be as objective as possible by “bracketing” which involves the researcher attempting to set aside their preconceptions, prejudices and beliefs so that they do not interfere with or influence the description of the subject’s experience. In other words one must set aside what is already known about the experience being investigated and approach the investigation with no pre-conceptions about the phenomenon.

Initially I believed that this study might employ Descriptive Phenomenology in that it would be attempting to illuminate the experiences of the subjects through their personal stories and describe their experiences. However, the more I explored this philosophy, the more I realised that it would be impossible to approach such an investigation with no pre-conceived ideas about the phenomenon. My concerns were supported by Koch (1995) who points out that as researchers we are interpreting something in which we ourselves exist and therefore we can have no detached standpoint. The fact that I have chosen this study as a result of a longstanding interest in this area and the fact that I have conducted an extensive literature review around the subject would make it extremely difficult, if not impossible, to “bracket” my past experiences related to the subject. In addition it is my intention that this study will do more than just describe the experiences of the subject, but that I may, through analysis of the data collected, be able to offer some interpretations of those experiences.

I therefore considered Interpretive Phenomenology, also known as Hermeneutics, which is generally accredited to Heidegger (1962) and is based on the premise that getting to know and describing the experience of individuals is not enough, but that we use our own experiences to interpret those of others. In other words we form our own subjective interpretations of the experiences of others. Parahoo (2006) explains that Heideggerian phenomenology seeks to find out how individuals' personal history, such as their education and social class, past events in their lives and their psychological make-up, influences the ways in which they experience phenomena. This seemed to fit more with my desire to hear the stories that individuals had to tell in relation to experiences with mathematics.

I then considered how I would analyse the data generated by the students' accounts of their previous experiences. As a result of my experience of working with students I anticipated that they would have stories to tell about those past experiences. Thody (1997) indicates that stories can be analysed using conventional techniques such as categorising and coding of content, thematization and concept building but Bryman (2004) points out that coding tends to fragment the data. Riessman (2004) has shown that narrative analysis can be applied to conventional interview transcript material, and Bryman (2004) also explains how narrative analysis can be applied to data that have been generated through a variety of research methods. However he goes on to argue that narrative analysis has also become a focus for an interviewing approach in its own right, i.e. a narrative interview in which the researcher sets out to elicit stories. Therefore narrative analysis, or narrative inquiry as the methodology tends to be known, has become a widely

accepted research method in its own right. Further exploration of this methodology persuaded me that it was a better fit to my research questions than interpretive phenomenology and therefore I decided to employ Narrative Interviews as the method for the qualitative stage of my study.

Narrative Inquiry

Squire et al (2008 p2) state that the term Narrative is a “popular portmanteau term in contemporary western social research” and that it is “strikingly diverse” in the way that it is understood. The terms story and narrative are often used interchangeably. Frid, Ohlen and Bergbom (2000) argue that this is inappropriate and can be a weakness in Narrative Inquiry. Squire et al (2008) go on to say that the definition of narrative is itself in dispute and that narrative research offers no automatic starting or finishing points. However, many authors of research texts do attempt definitions, at least of the context in which they are using the term. For example, Bryman (2004) suggests that Narrative Analysis is a term that covers quite a wide variety of approaches that are concerned with the search for, and analysis of, the stories that people employ to understand their lives and the world around them. The term is often used to refer to both an approach – one that emphasises the examination of the storied nature of human recounting of lives and events – and to the sources themselves, that is the stories that people tell in recounting their lives (Roberts 2002).

Bathmaker & Hartnett (2010) suggest that a narrative approach can be used to explore the experiences of a wide range of people including teachers, nurses, young people and adults, reflecting on learning and education at significant moments in their lives, which is specifically what I wanted to do

within this study. However, Clandinin and Connelly (2000) stress that narrative enquiry goes beyond the telling of stories and involves trying to make sense of life as lived. Bathmaker and Hartnett (2010) agree, claiming that, if used well, narrative can illuminate what troubles us, and Wright-Mills (1959) claimed that narrative is a way of linking personal troubles with public issues. Mathematics anxiety could be considered a personal trouble but it certainly becomes a public issue in the context of healthcare provision and safety.

All of this fitted particularly well with what I was hoping to achieve within the main study. However, before I could gather appropriate narratives, it was necessary to ascertain whether mathematics anxiety really was an issue for the student nurses with whom I worked, and to identify individuals for whom mathematics anxiety was a particular problem. Therefore the methodological approach employed was that of a mixed methods design, incorporating a survey of a cohort of students to gain primarily quantitative data and a qualitative stage using narrative inquiry as the method. The study was exploratory in that it aimed to “find out what is happening, particularly in little understood situations” (Robson 2002: p59).

The Survey Stage

The survey was a descriptive survey in that it was designed to measure the characteristics of a particular population (Gray 2004). Surveys of this kind are often used to identify the scale and nature of problems such as poverty, crime and health-related issues. In this study it was used to explore the extent of mathematics anxiety amongst a cohort of student nurses.

The purpose of the survey stage was three-fold. Firstly it provided some demographic information regarding the extent of mathematics anxiety within the cohort. Gray (2004) claims that the value of a survey is enhanced if comparisons can be drawn between different categories of respondents. These demographic data enabled comparisons to be made on the basis of age, gender and educational background to determine if there were differences in the levels of mathematics anxiety between different groups.

As previously stated, my perception was that mathematics anxiety was widespread amongst healthcare students within the faculty, but I recognised that, as I work in a support department, my perception is influenced, and may be skewed, by the students I work with, i.e. those seeking support. I am aware that there are many students within the faculty who do not access our services and possibly have little or no anxiety about mathematics. It was therefore important to set my work in context by objectively assessing the extent of mathematics anxiety within the cohort being studied.

The second purpose of the survey was to identify students who did experience mathematics anxiety, so that they could be invited to participate in the interview stage of the study. The interview stage involved students who gained a high or very high anxiety score in the survey stage volunteering to take part.

The third purpose of the survey was to establish any key themes to be explored within the interview stage. The identification of emerging themes or

commonalities influenced the development of questions for the interview stage.

A survey of all student nurses within the faculty would have been too large and impractical to conduct, but a survey of one typical cohort generated sufficient data to determine the appropriateness of continuing to the interview stage. Admissions statistics for the university's faculty of health (name withheld 2010) showed that almost 50% of undergraduate students are student nurses. A typical nursing cohort contains a diverse range of students in terms of age, ethnicity, access routes and educational background. The cohorts are also large (approximately 500 students) so one cohort was likely to be broadly representative of all student nurses within the faculty.

The various ways in which the survey could have been conducted were considered. It could have been postal, on-line or face-to-face. However Bryman (2004) stresses that with postal or e-mail questionnaires the response rate would be expected to be much lower than with a face-to-face approach. He adds that the response rate for on-line questionnaires would be even lower than for postal ones but that there is a substantial cost involved with posting. With both approaches it is likely that only those who have a particular interest in the subject area will respond. As the students I wanted to survey were actually attending taught sessions within the university, it made sense to utilise a face-to-face session and ask the students to complete the questionnaire within the classroom environment. Wright (2007) achieved a near 100% return rate by using this approach, and I was persuaded that it was likely to gain a higher return and a wider range of

responses than postal or e-mail questionnaires, and it would save the cost of postage. Therefore students were invited to take part in the study as part of a routine face-to-face classroom session. The invitation was made verbally but was also supported in writing in the form of a letter (see Appendix 1) which clearly explained the purpose of the research and what participation would entail. The concept of consent was explained and students were able to choose not to participate and those that did agree were able to withdraw at any time, should they have so wished.

A single cohort of BSc (Hons) Nursing students was selected for the study. It was important to survey the students when they were new to the programme, because the faculty has several strategies in place that attempt to reduce mathematics anxiety by building the students' confidence in their abilities, and it was important to conduct the survey before any potential impact of these strategies. Therefore the students were invited to participate in the survey during the first two weeks of the programme. The students had a routine "Introduction to Numeracy" (classroom-based) session where they had the opportunity to take part in a range of self-assessment exercises. Those students who consented to take part in the study also completed the data collection tool. The data collection tool was designed so that students could have their result returned individually as information regarding their score might have been useful to them in understanding their relationship with mathematics and when seeking further support.

The results were returned a few days later at an appropriate time in the students' timetable, when there were opportunities for them to ask questions

about their results privately if they wanted to. The results sheet that was returned to the student was the front page of the data collection tool. Once this was removed, there was no further identifying information on the assessment tool that was kept for analysis so, from this point on, the data were anonymous.

The data collected enabled exploration of the difference in anxiety levels between different demographic groups, such as gender, age and highest mathematics qualification. The purpose behind this was to enable the consideration of questions such as “is mathematics anxiety as widespread amongst school leavers entering higher education as it is amongst mature students?”, If it were shown to be that it was, this could suggest that the root causes of mathematics anxiety are still prevalent in our education system, and need exploring further. If the levels had shown to be significantly lower amongst school leavers this could have indicated that recent developments in educational management and current teaching strategies were already working to reduce the problem, or that the issue might have been more to do with experience post school-level education. In either case this would have influenced the focus of the second stage of the study.

Any potential gender differences were also explored, as Sabin (2001) argues that mathematical ability is socially constructed and that women are much more likely to underestimate their mathematics ability and be more prone to mathematics anxiety. The responses to the survey were analysed and the results presented using both descriptive statistics and statistical analysis. According to Gray (2004), one of the aims of descriptive statistics is to show

what the data are, as opposed to drawing conclusions beyond the data. In other words they describe the basic findings of the study, often through the use of graphical analysis.

Gray (2004) goes on to say that the use of charts or graphs certainly provide the potential for the communication of data in readily accessible formats. Therefore bar charts and tables were used to illustrate any differences in anxiety levels between different demographic groups, and appropriate statistical tests were used to determine the presence or absence of statistically significant differences between groups. These statistics were intended to demonstrate the extent of anxiety within the group, the further exploration of that anxiety was the basis of the interview stage of the study. The themes generated by the open questions in the data collection tool were collated and used to inform the questions used in the interview stage.

The Interview Stage

For the interview stage of the study it was intended that interviews would be undertaken with volunteers from the same cohort of students who demonstrated very high or high levels of mathematics anxiety, as determined by the data collection tool. The purpose of the interviews was to explore the students' feelings about and experiences related to numeracy or mathematics, and to identify if there were any prior experiences which they specifically associated with their anxiety.

A narrative approach had been adopted because it was felt that the students who agreed to be interviewed would have stories to tell related to their

previous experiences of mathematics. The students were invited by e-mail to participate in the interview stage if they had scored a very high or high anxiety rating on the AMAS part of the data collection tool, which they knew from the results that had been returned to them. It was intended to interview between 8 and 12 students depending on the number of volunteers and the amount of data that were obtained. If there had been insufficient volunteers, the criteria could have been expanded to include those with moderate as well as very high or high levels of mathematics anxiety.

It was recognised that students who volunteered their stories could have particular personal reasons for doing so which would mean that the data collected were not necessarily representative of the whole cohort. However these individuals were rich sources of data and there would have been little value in selecting individuals who were subsequently unwilling to share their experiences, or who did not feel that they have anything to tell.

According to O'Leary (2004 p199), the goal of Narrative Analysis is to "interpret the stories of individuals". Polit and Beck (2006) argue that this involves organising, structuring and eliciting meaning from the data. Different approaches to the analysis of narratives have been put forward but according to Gray (2004) they all have a number of common characteristics, including:-

1. The text is viewed in the Gestalt, that is within the context and social situation in which it was created. The Gestaltian notion of the whole being greater than the sum of the parts and the importance of seeing the big

picture aligns well with the concept of a meta-narrative (Andrews 2002). According to Andrews (2002), Meta-narratives, or larger stories, can constitute culturally dominant narratives which have the potential to inform and shape people's lives.

2. There is formal analysis of the text, including making distinctions between text that constitutes narrative passages and other forms of text.

Where researchers generally differ is in their attitude to the status of the text itself. While some take the truth of the narrative at face value, others see narrative as a special way of constructing events, that is to say "they are social constructions located within power structures and social milieu". (Punch 1998, p223). Bathmaker and Hartnett (2010) stress that the role of the researcher in interpreting the stories they are told is a significant one.

There are many ways in which narrative data can be analysed, but Riessman (2008) distinguishes four models:

- Thematic Analysis – an emphasis on what is said rather than how it is said.
- Structural Analysis – an emphasis on the way the story is related. Issues of content do not disappear but there is an emphasis on the use of narrative mechanisms for increasing the persuasiveness of the story
- Interactional Analysis – an emphasis on the dialogue between the teller of a story and the listener. Especially prominent is the co-construction of meaning by the two parties, though content and form are by no means marginalised.

- Performative analysis – an emphasis on narrative as a performance that explores the use of words and gestures to get a story across. This model of narrative analysis includes an examination of the response of an audience to the narrative.

One way of analysing the data would have been to use conventional techniques such as categorising and coding of content, thematization and concept building (Thody 1997) but the idea of coding was dismissed as I wanted to avoid fragmenting the data (Bryman 2004). The nature of the data collected did lend itself to thematic analysis and so this was the approach that was adopted. Bryman (2004) stresses that interviewing and the subsequent analysis of the data is complex. Gray (1998) also stresses that narrative interviews are particularly time-consuming as they require the researcher to allow the story tellers to recount their experience in their own way. However I was persuaded that this was the most appropriate means of data collection and analysis for this stage of this study.

Research Methods

It was recognised that in order to assess the extent of mathematics anxiety amongst the student cohort to be investigated, a form of measurement tool, i.e. a mathematics anxiety assessment tool was needed. After much exploration of existing tools available, an assessment tool consisting of three sections was developed (See Appendix 2). The first section consisted of some questions related to general demographic data which enabled me to explore whether there were any differences in anxiety levels related to age, gender or educational experience within the cohort.

The second section of the assessment tool was based on the Abbreviated Maths Anxiety Scale (AMAS) (Hopko et al 2003) (see Appendix 3). Professor Hopko's permission to use this tool was granted (see Appendix 4). This tool is a 9-item Likert-type questionnaire which presents the students with a range of scenarios and asks them to assess how they feel about them. This exploration of feelings related to specific event categories is particularly relevant to a qualitative study, and to this study in particular as it is how students feel about mathematics that is important rather than how good they are at it. As the tool is an established one, the event categories are pre-determined although they were modified slightly after the initial study (see initial study). The assessment takes just a few minutes to complete and has been shown to be particularly relevant for studies involving large numbers of undergraduate students. The two-week test-retest reliability was .85, which I considered to be sufficiently reliable for the purposes of this study.

The third section of the assessment tool asked students to draw a line on a graph representing how their feelings about mathematics have altered during their lifespan: the graph was a simple one with a horizontal mid-line representing neutral feelings. Any point above this line represented positive feelings, the higher the point the more positive the feelings being represented. Conversely, points below the line indicated negative feelings. Students were shown examples of how to plot the graph and care was taken to show positive, negative and neutral examples to avoid giving the impression that a particular pattern is expected. Whilst this was a very subjective account of the students' recall of their feelings, it did help to indicate if students associated any particular life stages or specific events

with a marked change in their feelings or attitude to mathematics. The students were also asked to write one word, phrase or sentence that summarised how they felt about mathematics at that point in time. The purpose of this item was to provide a statement with which to compare the student's AMAS score and the graph of their feelings, to ascertain whether their score fitted with how they reported to feel.

For the Interview stage of the study, individual interviews were conducted. The interviews were in-depth (Miller and Glassner 2011) and semi-structured (Cohen et al 2000), and incorporated the principles of narrative interviews. Focus groups were considered for this stage but, because I was interested in the personal narratives of individuals, this option was quickly dismissed because it was likely that each story would be unique and because of the potentially personal nature of some of the information that might have been given. The interviews were audio-recorded, with the students' permission, and transcribed.

Bryman (2004) explains that qualitative interviews give insight into what the interviewee sees as important. Therefore such interviews can provide access to people's knowledge about both the contexts in which they act and the other people involved in them. This was particularly relevant as students' stories inevitably included other key players such as former mathematics teachers or parents. Coffey and Atkinson (1996) stress that the aim of a narrative interview is to elicit interviewee's reconstructed account of connections between events and between events and contexts, which was particularly pertinent to this study. Miller and Glassner (2011) agree that in-

depth interview accounts provide a meaningful opportunity to study and theorise about the social world. They go on to argue that, specifically, interviews reveal evidence of the nature of the phenomena under investigation, including the contexts and situations in which it emerges, as well as insights into the cultural frames people use to make sense of these experiences and their social worlds. Therefore in-depth interviews were a particularly appropriate approach to gaining information about an individual's personal experiences related to mathematics.

Qualitative data were drawn from the students' personal stories, which Bauman (1986 p455) argues are rich in the subjective involvement of the storyteller, and offer an opportunity for the researcher to gather "authentic, rich and respectable data". I conducted all of the interviews myself. As students associate me with numeracy support provision within the faculty, many had already seemed very willing to share their personal experiences. In fact, it was from the stories that students have shared with me in the past that my interest in this area had arisen. However I was also aware of the potential for my role and experience to introduce bias.

The specific questions that were asked in the interviews could not be fully determined in advance as the objective was to elicit the students' personal account of their experiences rather than to ask a list of prescribed questions. However, after the results from the survey stage were analysed it was possible to identify themes for potential exploration during the interviews, as a result of the students' responses to the open questions. Within narrative interviews it is more important to identify the themes to be explored rather

than to have a list of specific questions to be answered. However, it was clear that as the researcher designing the interviews, I needed to have a repertoire of questions designed to elicit a narrative and, in this context, I considered the type of questions that would need to be asked. I could have tried just asking the participants to tell their story but Riessman (2008) argues that it is usually necessary to keep asking follow-up questions to stimulate the flow of details and impressions, and advises that questions like “tell me what happened” and “what happened next?” are most appropriate to this narrative style interview. Therefore the interview questions were open questions and prompts were used to encourage students to talk freely about their past experiences. This also aligned with advice from Gray (1998) who argues that narrative research requires the storyteller to be allowed to structure the conversations, with the researcher asking follow-up questions, meaning that a narrative approach to a question involves extended open interviews with appropriate subjects, which allow them to express their personal experience including problems, frustrations and joys.

Insider Research

According to Griffith (1998) an insider researcher is someone who has a lived familiarity with the group, for example they may have a shared gender, ethnicity or culture. For this study, I was an insider in that I was familiar with the requirements of the programme and to a large extent the anxieties of the students, many of whom I work with on a regular basis. Burgess et al (2006) claim that insiders are likely to possess this type of intimate knowledge of the community they are studying. On the other hand I was not, and never have

been, a full-time university student, so cannot claim to have shared the same experiences as the students who took part in the study. Mercer (2007) argues that it is more helpful to consider the issue of insider / outsider research as a continuum rather than a dichotomy and that as a researcher one moves back and forth across different boundaries. This concept fitted well with my perception of myself within this research study. I was not fully an insider in that I was not a student, but I did feel close to them and I felt a sense of responsibility towards them (Mercer 2007). In addition, I was not an outsider as I was effectively researching an issue closely related with my own area of practice, and I was an insider in the organisation in which the study was based.

Costley et al (2010) explain that organisational, professional and personal contexts will influence the way a piece of research is carried out. They add that the culture and structure of your work situation and the actions and thinking of colleagues is likely to shape your work. This was certainly true for this study. As I manage both the numeracy support and the staff delivering that support, I had to be sensitive to my colleagues' feelings and draw on their understanding and trust. In particular, it was important to be clear that I was not challenging their current practice, but trying to understand the prior experiences of some of the students we work with. However, Costley et al (2010) point out that the compelling rationale for insider research is to make a difference to the practice of that workplace.

The advantages of insider research are that the researcher can have a more empathetic understanding and they are better positioned to derive meaning

from their findings (Mercer 2007). It is also easier to gain access to the people you want to study, to have more credibility and to develop a rapport with them. The disadvantages are that it is possible to become too familiar and to overlook things that an outsider might see. It is also much more difficult to be objective, Le Voi (2000) argues that qualitative work necessarily entails involvement and cannot be done in an objective way if it is to yield any worthwhile insight into the informant's world. However, it may also be the case that some respondents may not share information with an insider, for fear of being judged. It is for this reason that I wanted volunteers who were willing to share their experiences to take part in the interview stage of the study. Mercer (2007) stresses that people's willingness to talk to you and what they say is influenced by who they think you are, and they may temper the truth in order to protect an on-going relationship. They may also make assumptions about what the researcher already knows therefore tailor their information accordingly. Griffiths (1998) argues that this means an insider simply produces a different knowledge and understanding to an outsider.

Hammersley (1993) argues that there are no overwhelming advantages or disadvantages to being an insider researcher. However there are a number of issues that need to be considered. The first is how much to reveal about oneself and the research (Mercer 2007). I decided that I could reveal quite a lot about myself and my research to the students, because I was interested in their experiences prior to university, so there were no significant conflicts of interest. However, I was aware that students might be guarded about what they would tell me in case it influenced any future relationship on the programme. I felt that the more I shared of my rationale for the study, the

more willing they might be to participate. Another Issue that needs to be considered is that of the power relationship. As a member of academic staff, I recognise that students might perceive me to be in a position of power, and Floyd and Arthur (2010) stress that power relationships are far more complex for insider researchers. It is important to take great care not to abuse that power. For example, I did not want any students to feel compelled to take part in the study and I went to great lengths to reassure them that there would be no penalty for choosing not to take part.

Another issue associated with insider research is bias, and as previously stated, I recognised that my own values and views would influence this study. According to Costley et al (2010), one way of reducing insider bias is to triangulate the research methods which I attempted to do by using a mixed methods approach.

Rigour

According to Holsten and Gubrum (2011) all interviews are unavoidably interactional and constructive and both the interviewer and the interviewee are implicated in the construction of the resulting narrative reality. Therefore interviews can never be completely free of bias. Nonetheless, as Long and Johnson (2000) argue, all research studies must be open to critique and evaluation and there is a clear imperative for rigour to be pursued in qualitative research so that findings may carry conviction and strength. Saumure and Given (2008) explain that rigour is best thought of in terms of the quality of the research process. They go on to add that rigorous qualitative research requires transparency, reliability or dependability, validity or credibility and reflexivity. In order to provide transparency, I attempted to

give a clear and detailed account of the methods used, the data collection and the data analysis. I also aimed to provide a plausible and coherent explanation of the findings.

Reliability and validity are terms that are generally applied to quantitative research, whereas dependability and credibility are more often aligned with qualitative approaches. However some authors (Long and Johnson 2000) argue that they are effectively the same thing. Holsten and Gubrum (2011) argue that whilst rigour is conventionally assessed in terms of reliability and validity, different criteria apply when the interview is viewed as a dynamic meaning-making occasion.

Reliability is related to the consistency of the data, i.e. that the data collection tool would enable the same data to be obtained at a different time or by a different researcher. Long and Johnson (2000) state that reliability can be enhanced by standardising data collection and building in alternative forms of a question, which can then be used to check consistency. In order to maximise the reliability of my data from the survey stage, I designed a data collection tool that was based on a standardised assessment tool that had previously been used and assessed for reliability. The Abbreviated Maths Anxiety Scale (AMAS) developed by Hopko et al (2003) is a widely accepted modified version of the original Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn (1972) who undertook an intensive study to test and subsequently demonstrate the reliability and validity of the tool. In addition to the AMAS I also included a section for students to plot a graph of their feelings towards mathematics and to give a word, phrase or

sentence to summarise their feelings. The graphs and comments were compared with the AMAS score to assess consistency.

Seale and Silverman (1997) argue that in qualitative research, authenticity rather than reliability is often the issue. I therefore used open-ended questions within the interviews in order to enable students to tell the story of their own experiences related to mathematics in their own words. I also audio-recorded and carefully transcribed all of the interviews as Seale and Silverman (1997) argue that recordings and transcripts offer a highly reliable record to which the researcher can return time and time again.

Validity is the extent to which the data collection methods measure what it is you want to measure, or collect the data that you need. Hammersley (1992) states that in qualitative research an account is valid or true if it represents accurately those features of the phenomenon that it is intended to describe. He goes on to say that no knowledge can be counted as certain, but that it is the quality of the evidence that upholds the claim. I therefore paid a great deal of attention to the construction of the data collection tool and the design of the questions for the interviews. In addition I asked both colleagues and students to review the data collection tool and revised it accordingly before conducting a small pilot study. The interview questions were based around the themes that emerged from the survey stage, but were flexible in order to allow the participant to tell their story in their own way.

Long and Johnson (2000) claim that the credibility of a study is enhanced when the data are triangulated. Bryman (2006) also argues that corroboration between quantitative and qualitative data provides triangulation

and enhances the validity of the findings. Triangulation means the use of multiple data sources, collection methods or investigators. I did not want to use multiple investigators as I felt this would detract from the consistency of the data collection, but I did use multiple data collection methods in that I used both a survey and interviews. In addition the data collection tool incorporated three different means of gathering information regarding the students' level of anxiety and their feelings towards mathematics.

Seale and Silverman (1997) outline a number of other methods which can be employed to ensure rigour. These include recognising the importance of representation sampling, as opposed to random sampling, and supporting generalisations by counts of events. I did recognise the importance of representation sampling in that by asking for volunteers for the interview stage I recognised that those who volunteered their stories could have particular personal reasons for doing so. This could mean that the data collected were not necessarily representative of the whole cohort, but the data were much more likely to be representative of those with high levels of mathematics anxiety. These individuals were rich sources of data and I noted within the methodology that there would have been little value in selecting individuals who were subsequently unwilling to share their experiences, or who did not feel that they have anything to tell. As part of the presentation of the results and subsequent data analysis of the interviews, I recorded the number of students that had made similar comments or expressed similar views. Therefore, I have used a variety of approaches to ensure that the study is as rigorous as possible throughout.

Ethical Issues

As with any research study, there were a number of ethical issues which needed to be considered. These included informed consent, confidentiality and a consideration of the potential emotional impact of involving students within the study.

Informed Consent – The students invited to take part in the survey were fully informed of its purpose and did not need to participate if they did not wish to do so. Those who did consent were able to withdraw their participation at any time if they so wished. Those taking part in the individual interview stage were invited to participate, but were also able to withdraw at any point if they so wished. It was important that the students were aware of this as the British Educational Research Association (BERA 2004), in its Revised Ethical Guidelines for Educational Research, stresses that researchers must take all necessary steps to ensure that all participants in the research understand the process in which they are going to be engaged, including why their participation is necessary and how any information collected will be used. They go on to say that researchers must recognise the right of any participant to withdraw from the research for any or no reason, and at any time, and they must inform them of this right. Therefore the research and the students' right to decline was explained both verbally and in writing (see Appendix 1) before they were invited to participate. This was particularly important as the students were new to the university and it was recognised that as I was a member of academic staff, they may well perceive me to be in a position of power, and feel obligated to take part. It was therefore necessary to emphasise, both verbally and in writing, that a decision not to

participate, or a decision to withdraw, would have absolutely no impact on their subsequent studies or on the support that was available to them. Any students who did withdraw part way through the interview would be asked whether the information they have given so far can be used for the study. If they did not consent, it would not have been used.

Confidentiality – the students initially had the option of including their name on the front of the data collection sheets so that results could be returned to them for their own information and personal development planning. This personal information was recorded on a detachable page that was returned to the students with their anxiety score. The remaining pages kept for analysis were anonymous. In addition students did not need to enter their name if they did not wish to do so. For the interviews, confidentiality was maintained at all times and any identifying information was omitted from the transcriptions of the audio-recordings prior to analysis. The interviews were conducted within a quiet private tutorial room within the university. It was anticipated that they would take between 45 minutes to an hour but that they could be longer or shorter depending on the participant, their willingness to talk and the amount of information they had to offer. BERA (2004) emphasises the importance of confidentiality and anonymity, arguing that the confidential and anonymous treatment of participants' data should be considered the norm for the conduct of research.

Emotional Impact – BERA (2004) states that researchers must recognise that participants may experience distress or discomfort in the research process and it was recognised that students might become emotional when

sharing personal stories. In order to reduce the sense of intrusion and put the students at their ease, all interviews were conducted in a quiet, private room and participants were assured that they could decline to answer any question they were not comfortable with. They were also reassured that they only had to give information that they were happy to share and that they could stop the interview at any time if they so wished. If they did wish to withdraw, they would be offered the option of having any data already collected being excluded from the study. Should a student have become unduly upset or distressed, the interview would have been suspended or terminated as appropriate. The student would have been allowed time to recover and talk about the issue if they wished, but this discussion would not have been recorded or used within the study. The student would also have been provided with details of the university's counselling services if necessary.

Survey Saturation - whilst survey saturation is not an ethical issue as such it was important to consider it in the context of the overall student experience, and within the faculty it was a factor that would have been considered when deciding whether to grant permission for the study to be undertaken. There is a risk that survey saturation may become a problem for students, but this survey was carried out in the first week or two of the programme (before students can engage in any of the existing numeracy support provision) so this should not have been a problem at this stage. In addition, summative numeracy tests form part of the students programme and therefore self-assessment and formative assessment activities at the beginning of the programme were already current practice. The anxiety assessment tool used for this study was given alongside routinely offered self-assessment tests

and doubled as a diagnostic tool for the students, who were informed of their results on an individual basis. This might have been beneficial to them in identifying their own individual learning needs, and perhaps understanding a little more about their personal relationship with and reaction to mathematics. Support was already in place to help them address any identified learning needs.

Ethical Approval. Approval from the Open University's Human Research Ethics Committee (HREC) was required for this study and was gained in July 2011 (see Appendix 5). In addition, because the participants were students of the university, approval was also required from the faculty's Academic Sponsorship and Indemnity Committee. This is because there is always a possibility, in any research project, that something may go wrong or that people may get hurt in ways that could not have been foreseen. In order to protect both the researcher and the participants, the Department of Health's (DOH 2005) Research Governance Framework for Health and Social Care sets out the broad principles of good research governance and requires all researchers to ensure that indemnity insurance is in place before they begin their investigations. To obtain this insurance, each project must have a sponsor; an organisation willing to provide indemnity insurance. Sponsors must satisfy themselves at the outset that a project is sound, that it will be managed correctly, that the researcher has the expertise required and that appropriate resources are in place. The sponsor's role is to ensure that the proposed research is worthwhile and represents value for money. Once the research begins, the sponsor continues to be responsible for ensuring that any significant changes or developments are dealt with appropriately. Within

the Faculty of Health, the Academic Sponsorship and Indemnity Committee fulfil the sponsor's role on behalf of the University. This committee has approved the conduct of this study (see Appendix 6).

So, in summary, a mixed methods approach was employed and a two-stage study was designed. Ethical approval was gained. The first stage was a survey of one cohort of student nurses to determine the extent of mathematics anxiety within the cohort, to identify students with high levels of mathematics anxiety for potential inclusion in the second stage, and to generate themes for questions in the interview stage. This involved the use of an established data collection tool which has been trialed, and further modified, as part of an initial pilot study. The second stage was in-depth, semi structured interviews with students who demonstrated high or very high levels of mathematics anxiety to explore any experiences they associated with why, when and how that anxiety developed.

Chapter 4: The Initial Study.

The purpose of an initial study is to clarify and consolidate the focus of the research study and can be a pilot study of the research tool that is intended to be used for the main study (Open University 2005). Therefore this initial study was firstly a review and then a pilot of the data collection tool that had been developed, incorporating Hopko et al's (2003) Abbreviated Maths Anxiety Scale (AMAS) assessment tool. As a result of the review further modifications to the data collection tool were made.

The Data Collection Tool.

The original AMAS assessment tool (Hopko et al 2003, see Appendix 3) was designed for use in the USA, so some of the wording needed to be modified to be more suitable for UK students, before being used for the study. For example the statement "being given a pop quiz in a math class" was modified to "being given a maths quiz in class". The term math was changed to maths throughout as this is the usual convention in the UK. McGee and Notter (1995) stress the importance of ensuring that the questions on the data collection tool need to be clear, precise and unambiguous, and that meaning should be straightforward and not difficult to understand. Therefore it was important to translate the American-style phrases into UK English in order for it to make sense to the students.

In addition it was felt that some students may not associate themselves with the first statement "having to use the tables in the back of a math book" so this was altered to a more general mathematics usage statement "having to use maths in everyday situations e.g. dividing a restaurant bill". The original

statement reflects a behaviourist approach to the learning of mathematics, which is aligned to the absolutist philosophy, in that it represents a highly structured, student exercise based approach to learning (Threlfall 1995). A question related to using mathematics in everyday situations reflects a real world example (Weeks et al 2001) and reflects a constructivist approach to learning which aligns with the fallibilist philosophy of mathematics. This meant that the new statement was not directly equivalent to the original statement, in that it now reflected a situation that students may feel considerably less anxious about. However, it was felt that this would have more meaning to the participants and therefore be more useful in ascertaining their feelings towards mathematics.

In statement 3, “watching a teacher work an algebraic equation on the blackboard” was initially changed to “maths equation” as it was felt that students might not recognise algebra as a skill generally required by nursing practitioners and it was the students’ feelings about mathematics generally that was of interest not their feelings about a specific area of mathematics such as algebra. It may be possible that a student could be very anxious about an algebraic calculation but not nearly so anxious about more general mathematical functions. However this statement was subsequently changed again, in response to feedback from the review group, to become “Watching a teacher work out a long division question on the board”.

The original AMAS consisted of a list of statements against which students wrote the number which they felt corresponded their level of anxiety related to this item. For this study the items were formatted into a table layout

enabling the student to just tick the box with the appropriate response. The reason for this was that not only would it be more straightforward for the student to complete but that it would also aid the collation of responses for the purpose of analysis. The AMAS consists of nine items each being scored on a scale of 1 to 5, with 1 representing “low anxiety” and 5 representing “high anxiety”. Therefore 9 is the lowest possible score and 45 the highest. The following scale was devised by Hopko et al (2003) to categorize the scores:-

Score	Level of Anxiety
9	Low
10 - 18	Mild
19 - 27	Moderate
28. 28 - 36	High
37 - 45	Very High

In addition to the nine items included in the AMAS tool, two further sections were added to create the data collection tool for use for the initial study (see Appendix 2). The first section is included to record some general demographic data, including age, gender and highest mathematics qualification to enable comparison between groups. The final section includes a graph on which students were asked to draw a line representing how their feelings towards mathematics had altered during their lifespan and

a request to write one word, phrase or sentence that summarises how they felt about mathematics. The purpose of this item was firstly to provide a statement with which to compare the student's AMAS score, i.e. to consider whether the comment they made fitted with the AMAS score they gained. Secondly, these comments also enabled the identification of emerging themes or commonalities in the students' reported feelings, which helped with the development of questions for the interview stage.

The Data Collection Tool (the modified AMAS items plus the two additional items) was initially given to seven willing colleagues (university lecturing staff) to review, and then to a group of eleven first-year student nurses. These students were existing students who had been in the university for a few months, so they were slightly different from the study group which would be students in the first two weeks of their programme. They were asked whether the questions made sense, whether it was clear what was being asked and whether they felt that the score they achieved was an accurate representation of their feelings about mathematics. The results from these two groups were not to be used in the main study but attempting to complete the data collection tool enabled both colleagues and students to discuss and criticise it and suggest potential modifications.

As a result of this review there were two key areas that were identified as "not feeling right". The first was the levels of anxiety identified for scoring. One student said that she actually did not feel any anxiety at all about some of the situations identified and that therefore the first option should be "no anxiety". Others questioned the difference between "quite a bit of anxiety"

and “moderate anxiety” and suggested that to them this meant the same. It was therefore decided that the categories should be changed as follows:

No Anxiety = score 0

Little Anxiety = score 1

Some Anxiety = score 2

Moderate Anxiety = score 3

High Anxiety = score 4.

The student group unanimously agreed. Therefore a subsequent modification of the scoring was also required as follows;

Score	Level of Anxiety
0	No Anxiety
1 - 9	Mild
10 - 18	Moderate
19. 19 - 27	High
28 - 36	Very High

The second area identified by both colleagues and students was item 3 “watching a teacher work out a maths equation on the blackboard”. This is the item that had been changed from Hopko’s original statement which was “watching a teacher work an algebraic equation on the blackboard”. It had been changed because algebra might not be an area of mathematics that

student nurses recognise as being relevant to their practice. However, it was identified by the students that it would depend on the type of mathematics that was being worked out as to how one might feel. One student indicated in quite graphic language that they would not be particularly concerned about a multiplication exercise but they would indeed feel very uncomfortable if it were calculus. Whilst rather an extreme example, in that student nurses would not be required to use calculus, the point was well made and after some discussion it was agreed that the statement would relate to a long division question. Division *is* a skill required by student nurses and it was one that appeared to divide the group quite acutely on comfort levels. One student commented “I think if you’re OK with long division, you’re pretty OK with maths generally!” and none of the others disagreed.

It was also suggested by one member of the group that the word blackboard is “not considered politically correct these days”. Whilst not true, this invoked quite a lot of discussion from which there was no real consensus. However, it was acknowledged that it is very unusual to see a blackboard nowadays with most places having white boards, flipcharts or projectors. It was therefore agreed that using the term *board* was more generic and would not alter the meaning of the question. Therefore the statement was changed to “watching a teacher work out a long division question on the board”.

I acknowledge that by this point the assessment tool was no longer true to the original trialled and tested by Hopko et al (2003) but it did now ask what I wanted it to ask and there was agreement amongst the review group and myself that it meant the same to them as it did to me. Therefore I am

confident that the revisions ensured that the data collected were appropriate and of value.

Pilot Study

The second stage of the initial study was a small pilot study of the data collection tool. This was conducted a year before the main study with a group of 23 student nurses who were invited to participate in the study during the third week of their programme. The students were attending a routine introductory mathematics session that included a number of self-assessment exercises. The purpose of the study was explained and students were reassured both verbally and in writing (see Appendix 1) that there was absolutely no obligation to participate, and that a decision not to participate would not affect any subsequent mathematics support offered. All students were given a copy of the data collection tool and told that they could look through it before deciding whether to fill it in or not. Those not wishing to participate should just return the form blank and need not indicate to me or their peers whether they had completed it or not. All 23 forms were returned completed, which aligned with the near 100% return rate that Wright (2007) achieved using a similar face-to-face approach.

The results obtained (see Appendix 7) were briefly analysed using descriptive statistics to ascertain whether these types of data would be useful if gathered from the larger scale study.

Data Analysis of Pilot Study

Anxiety Levels. Of the 23 students, two (8.6%) scored Very High on the anxiety rating scale. Seven (30.4%) scored High, seven (30.4%) scored

Moderate, four (17.4%) scored Mild and three (13.0%) scored No Anxiety.
(see Fig. 3)

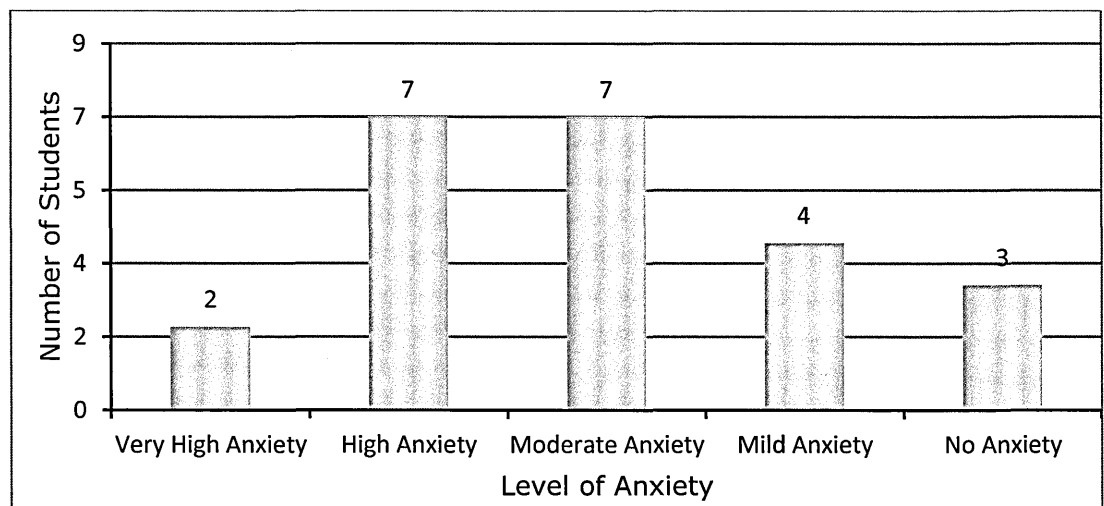


Fig. 3: Reported mathematics anxiety levels within the group of students who completed the pilot study.

Therefore, overall 69.6% of the group reported moderate, high or very high levels of anxiety related to mathematics. This is considerably higher than was anticipated, although it was recognised that it is not possible to generalise from such a small number of students.

Gender. Of the 23 students, 14 (60.9%) were female and nine (39.1%) were male. Eleven females (78.6%) indicated moderate, high or very high levels of anxiety, compared to five (55.6%) of the males. (Fig. 4)

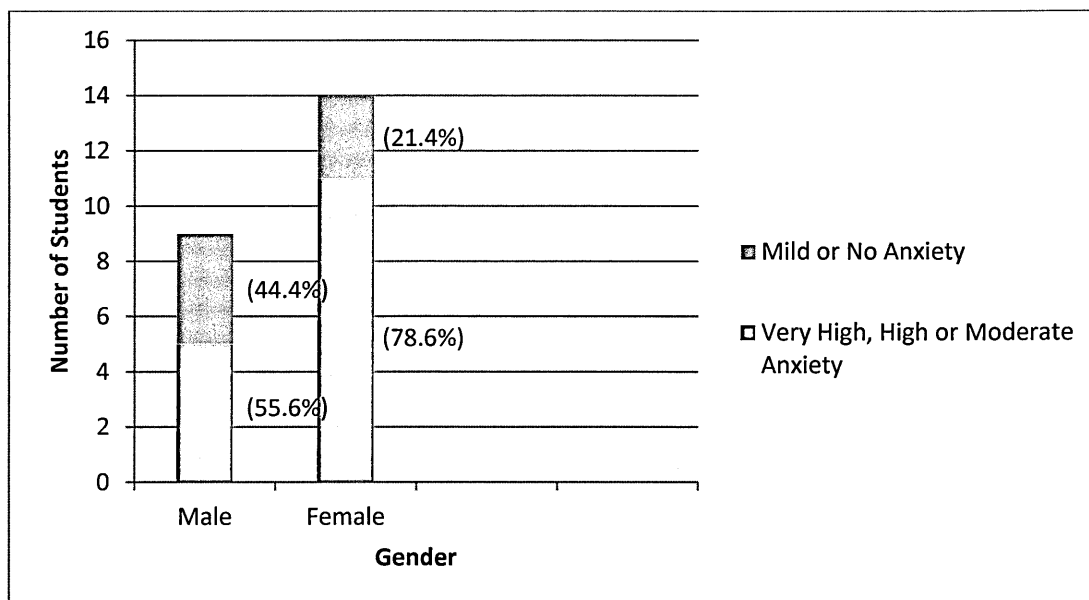


Fig. 4: Mathematics anxiety levels in male and female students (Pilot)

It did appear to be the case that, within this group, anxiety levels were higher in females, as suggested by Geist (2010) and Sabin (2001) but a survey of a larger cohort would give a clearer picture of any gender differences amongst the wider student population within the faculty.

Age. Nine students (39.1%) were in the 18-20 age category, seven (30.4%) were aged 21-30, three (13.0%) were 31-40, three (13.0%) were 41 – 50 and one (4.3%) was 51+. Of those aged 18-30, ten (62.5%) demonstrated moderate, high or very high anxiety levels, compared to five (71.4%) of those over 30. However as there were only seven students in the over 30 categories it is not possible to determine if there is any real difference related to age (see Fig. 5)

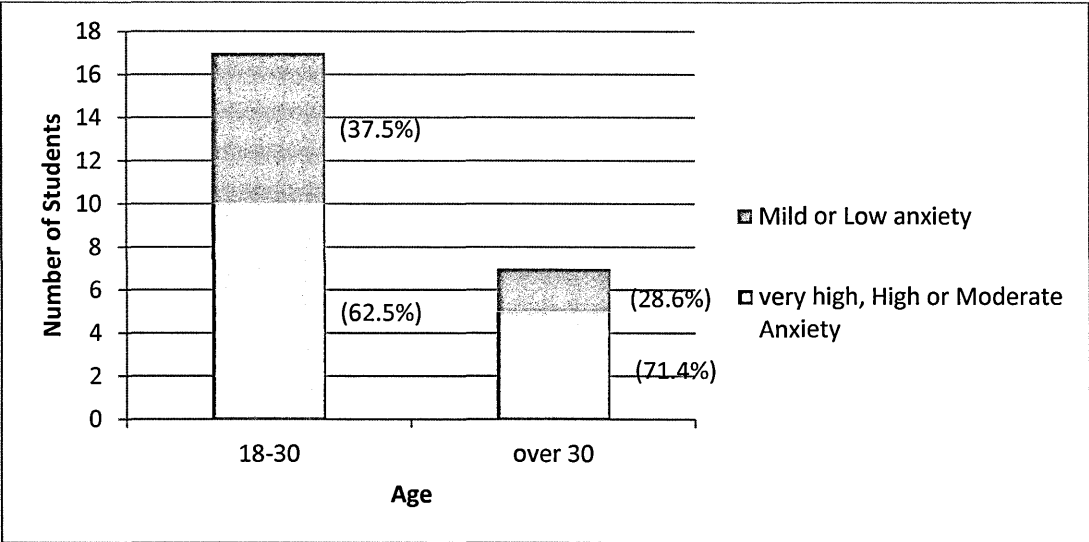


Fig. 5: Mathematics anxiety levels according to age (Pilot)

Only three students within the group (13.0%) had mathematics qualifications higher than GCSE or equivalent. Not surprisingly these all reported mild or no anxiety related to mathematics. Six students (26.0%) had completed part or all of their education outside of the UK. Of these, five (83.3%) reported moderate, high or very high anxiety levels.

The graphs on which students plotted their feelings about mathematics across their lifespan were interesting. Not surprisingly those who reported no anxiety plotted graphs that were all positive (e.g. see Fig. 6).

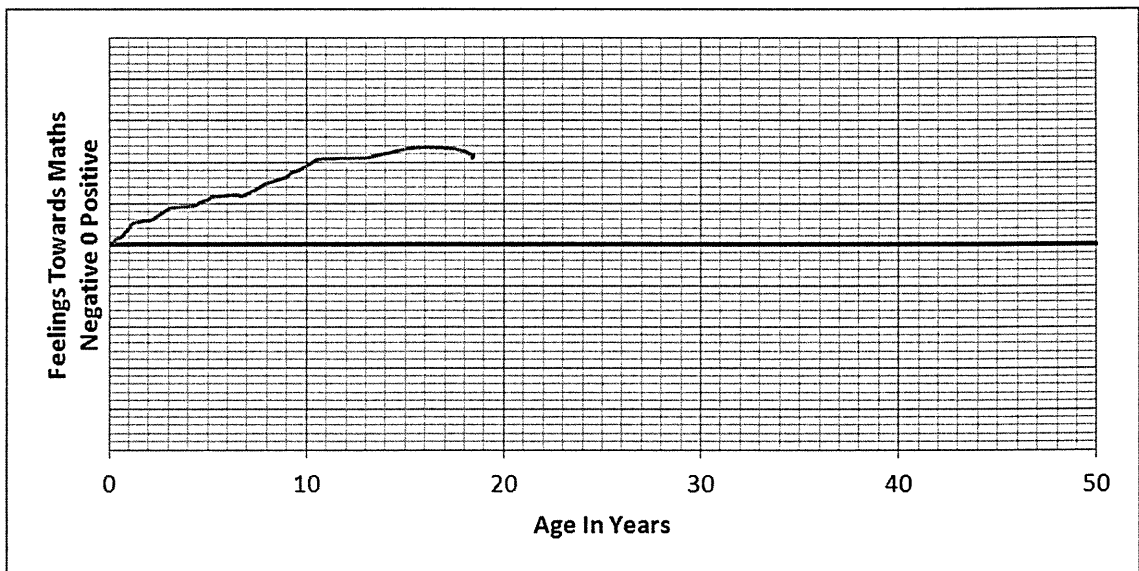


Fig. 6: Graph drawn by student (5) who reported *no mathematics anxiety* (Pilot).

However a total of ten students (43.5%), including one who reported only mild anxiety, plotted a marked dip from positive to negative during their teens (e.g. see Fig.7).

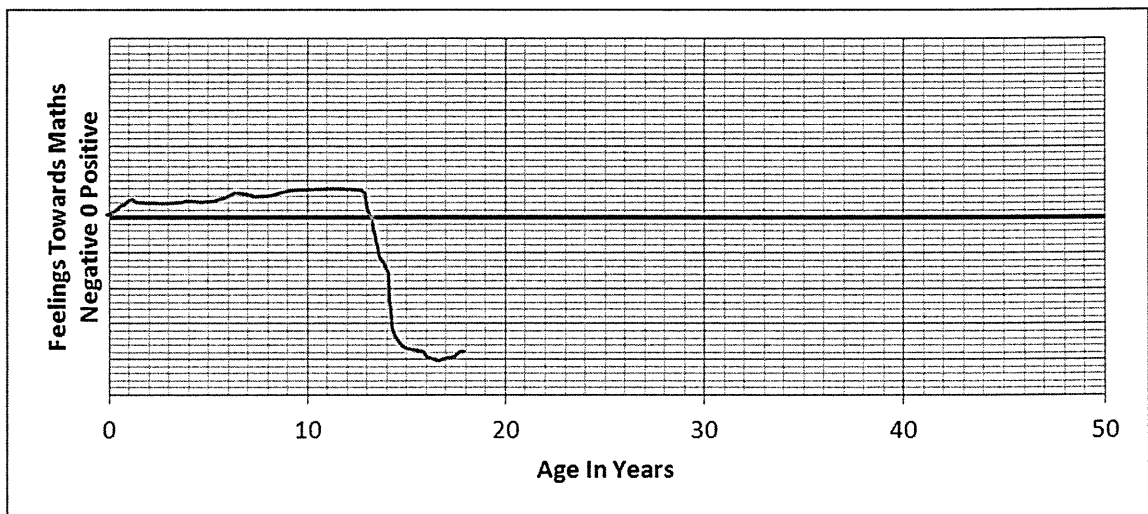


Fig. 7: Graph drawn by student (10) who reported *high mathematics anxiety* (Pilot).

It was felt that this would certainly be an interesting issue to explore with individuals during the interview stage of the study as it did suggest that some students associated a particular stage in their life with a marked change in

their feelings towards mathematics, and therefore may be able to relate a particular experience to this marked change.

This brief data analysis did persuade me that the survey stage of the study was necessary and would generate some useful data as well as identifying key themes to be explored further within the interview stage. I therefore conducted the survey with a whole cohort of students, prior to conducting in-depth interviews with a small number of students who reported high levels of mathematics anxiety.

Chapter 5: The Main Study – Survey Phase

The cohort of student nurses that were studied consisted of 518 students and of these 465 attended the Introduction to Numeracy sessions and were invited to participate in the survey. In total, 423 completed questionnaires were returned, which is a response rate of 91%. Although this was not the near 100% return rate achieved by Wright (2007), it was a very satisfactory return rate and the fact that some students chose not to participate provided reassurance that it had been made very clear that there was no obligation to take part. This is supported by Clark and McCann (2005) who in their own study identified the return of blank forms as reassurance of an effective method of ensuring that those choosing not to participate could not be identified.

The results were firstly analysed manually to provide some descriptive statistics and then using SPSS version 19 (IBM SPSS 2010) to carry out statistical tests for significance of the findings.

Results, Data Analysis and Findings – Survey

Of the 423 students who completed questionnaires, 29 (6.9%) scored *Very High* on the anxiety rating scale, 121 (28.6%) scored *High*, 138 (32.6%) scored *Moderate*, 123 (29.1%) scored *Mild* and 12 (2.8%) scored *No Anxiety*. (See Fig. 8)

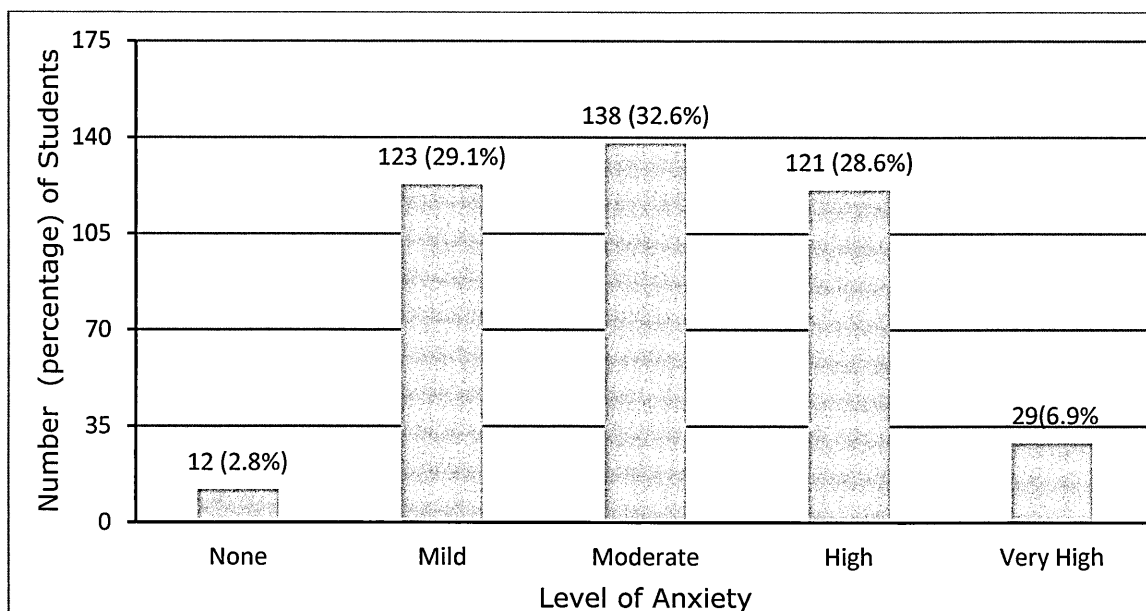


Fig. 8: Reported mathematics anxiety levels within the group of students who returned questionnaires

In total 68.1% of students reported a moderate, high or very high level of anxiety. This is considerably higher than Mackenzie (2002) found when she undertook a study of the level of mathematics anxiety amongst the students attending the HE College in which she was working, where 25% admitted to some current concern and avoidance of mathematics learning. Of course factors such as the type of course the students were on, what stage they were at and the way in which this data were collected have not been taken into account when making this comparison.

Gender.

Of the 423 students, 382 (90%) were female and 41 (10%) were male. For the number and percentage of males and females in each level of anxiety category, (see Fig. 9).

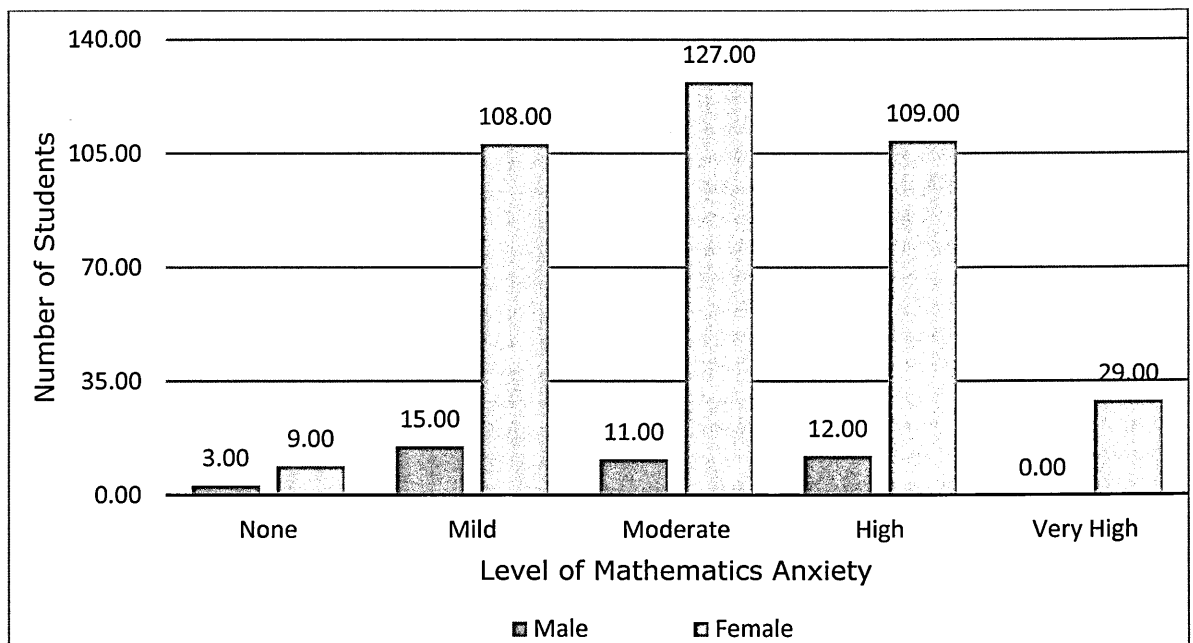


Fig. 9: Mathematics anxiety levels in male and female students

As there were two distinct groups, male and female, an Independent-samples t-test was conducted using SPSS version 19 to determine whether the difference in anxiety was statistically significant. In order to justifiably run the t-test, the data need to satisfy 5 assumptions (Pallant 2010);

- 1) Dependent score should be interval or ratio (and continuous)
- 2) Scores are obtained using a random sample from the population
- 3) Independence of Observations (different people in each group)
- 4) Dependent variable must come from a normally distributed population
- 5) Homogeneity of Variance

In this case gender will be the categorical independent variable and the numerical anxiety score will be the continuous dependent variable. It is necessary to use the actual anxiety score rather than the level of anxiety category (i.e. Very High, High, Moderate, Mild or None) as the category would be ordinal level data. Although the anxiety score data are not strictly

continuous, in that there are no mid-point values for example, the range of possible values (0 – 36) is large enough for this to be a reasonable approximation in this instance.

A t-test is a parametric test, and Pallant (2010) explains that whilst parametric tests are more powerful than their non-parametric counterparts, they do have more strings attached in that they make more stringent conditions about the data. Two key assumptions are that the data have approximately equal variance and reflect a normal distribution of scores. Levene's test of the equivalence of variance for the two groups gives a significance level of $p = 0.917$. Therefore the data adhere to the assumption of equal variance. For the group of females the distribution of anxiety scores is shown in Fig. 10 below along with a normal distribution curve fitting the data. We can say that a normal approximation to the distribution is reasonable in this case (with the caveat that the t-test is widely considered to be robust with a sample of this size (Pallant 2010)). For the male group the sample size was not large enough to give a visual confirmation of normality. However as the sample size (n) for males was 41 (i.e. bigger than 30 as advocated by Pallant) we can use the central limit theorem to assume normality (Pallant 2010). There were no missing data related to gender.

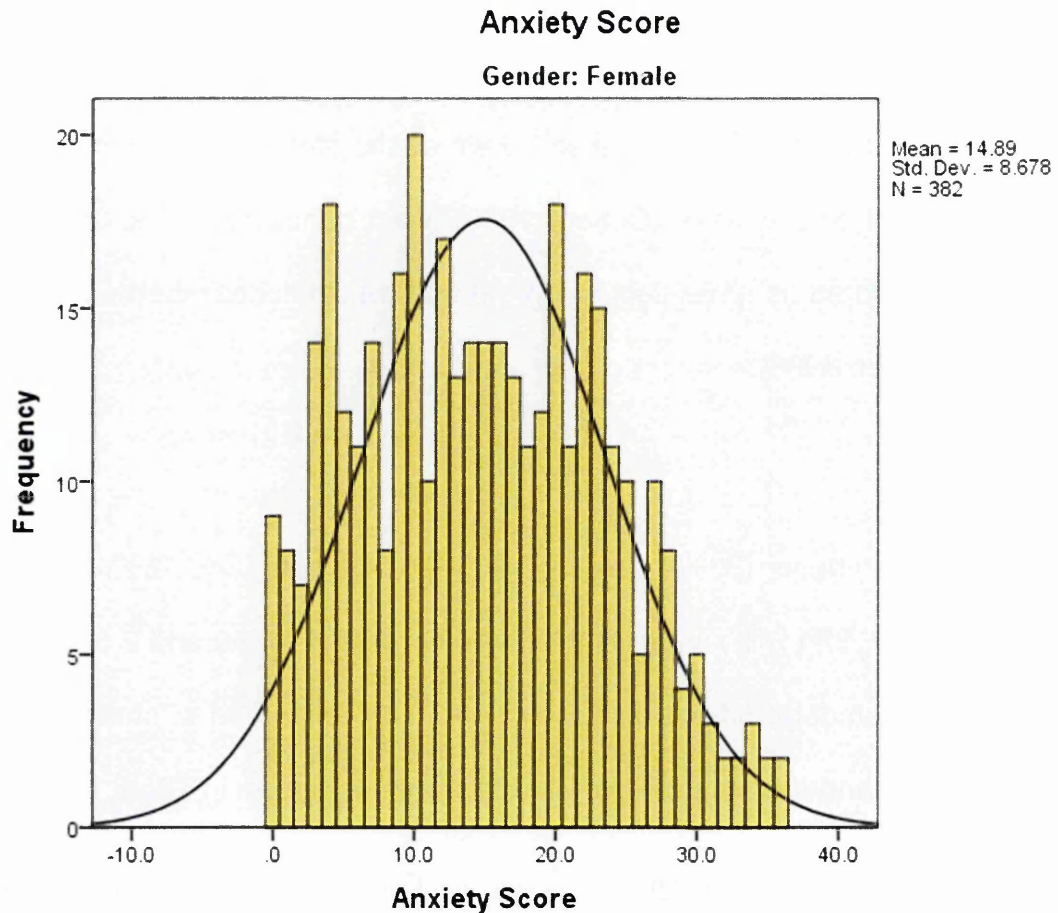


Fig.10: Distribution of anxiety scores for females within the sample (n = 382)

An independent samples t-test was conducted to compare the anxiety scores for males and females. There was a significant difference in scores for males ($m = 12.07$, $sd = 8.37$) and females ($m = 14.89$, $sd = 8.68$) $p = 0.048$, two-tailed. This test shows that there was a statistically significant difference in the mean scores of the two groups. The magnitude of the differences in the means is 2.81.

However, Pallant (2010) points out that there is more to research than obtaining a statistically significant result, and that what the probability values do not tell you is the degree to which the two variables are associated with one another. With large samples (which this is) even very small differences between groups can become statistically significant, which does not mean

that the difference has any practical or theoretical significance. She goes on to say that one way you can assess the importance of your findings is to calculate the *effect size* also known as the *strength of association*. Therefore a Cohen's d test (Cohen 1988) was conducted. The effect size was calculated as η^2 (eta squared) = 0.009, which is described as a "small effect" (Cohen 1988).

Age.

141 students (33%) were in the 18-20 age category, 183 (43%) were aged 21-30, 72 (17%) were 31-40, 24 (6%) were 41 – 50 and 2 (0.5%) were 51+. One student did not give their age. The proportion of students within each age band showing different levels anxiety is shown in Table 1.

Table 1. The number and percentage of students in each age band showing different levels of mathematics anxiety

	Very High	High	Moderate	Mild	None
Age 18 - 20	4 (2.8%)	35 (24.8%)	52 (36.9%)	46 (32.6%)	4 (2.8%)
21 - 30	15 (8.2%)	58 (31.7%)	57 (31.1%)	50 (27.3)	3 (1.6%)
31– 40	8 (11.1%)	21 (29.2%)	19 (26.4%)	20 (27.8%)	4 (5.6%)
41 - 50	2 (8.3%)	6 (25%)	10 (41.7%)	5 (20.8%)	1 (4.2%)
50 +	0 (0%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)

In order to statistically analyse these data, both a parametric and a non-parametric test were considered. The parametric test of choice for these types of data (comparing more than two groups) would be an Analysis of Variance (ANOVA) test. In order to justifiably run the ANOVA test, the data need to pass 6 assumptions (Laerd Statistics 2013);

- 1) Dependent score should be interval or ratio (and continuous)
- 2) Need to have more than 2 categorical independent groups (otherwise a t-test would be used)
- 3) Independence of Observations (different people in each group)
- 4) No significant outliers
- 5) Dependent variable must come from a normally distributed population
- 6) Homogeneity of Variance

Again, as argued above, there is a question as to whether the dependant variable is truly continuous (Assumption 1), but in addition Assumption 5 is not met in that only one of the groupings could be shown to represent a normal distribution using SPSS (IBM SPSS 2010) to conduct a Shapiro-Wilk test. Therefore as the data did not meet all of the criteria, the non-parametric equivalent was used which is the Kruskal-Wallis (KW) test.

Kruskal –Wallis Test of Differences in Anxiety Across Age Groups.

Firstly a KW test was performed on the whole group, looking for differences between different age bands. (see Table 2)

Table 2 – Results of Kruskal-Wallis test between different age categories

	Anxiety Score
Chi-Square	9.899
df	4
Asymp. Sig.	.042

The KW test revealed a statistically significant difference in anxiety scores across the five different age groups (Gp1, $n = 141$: 18 – 20 yrs, Gp 2, $n = 183$: 21 – 30 yrs, Gp 3, $n = 72$, 31 – 40 yrs, Gp 4, $n = 24$: 41 – 50 yrs, Gp 5, $n = 2$: 51+ yrs.) $p = 0.042$. However from the mean rankings for each age group it was not clear which group was the most influential in the above significance.

The data were then split according to gender (see Table 3) and in this case a subsequent effect size calculation was also carried out.

Table 3 – Results of Kruskal-Wallis test between different age categories split by gender

Gender		Anxiety Score
Female	Chi-Square	8.990
	df	3
	Asymp. Sig.	.029
Male	Chi-Square	3.442
	df	4
	Asymp. Sig.	.487

Table 3 shows that there was only a statistically significant difference between age groups amongst females. The age groups 21-30 and 31-40 recorded higher proportions of anxiety compared to the other age groups. The lack of significance between male groups is almost certainly due to the small sample size.

Effect Size.

As the KW is non-parametric, the Cohen’s d test cannot be used for effect size, so instead the ‘r’ value was calculated using a series of Mann-Whitney U tests. Cohen (1988) suggests the following criteria for the r values: 0.1 = small effect, 0.3 = medium effect and 0.5 = large effect.

For females a comparison between all groups consistently revealed a small effect size, ranging between 0.07 (comparing group 1: 18 - 20 yrs and group 4: 41 -50yrs) and 0.16 (comparing group 1: 18 - 20 yrs and group 2: 21 –

30yrs). For males the effect size was generally larger, ranging from 0.112 (comparing group 1: 18 – 20 yrs) and group 3: 31 – 40yrs) to 0.58 (comparing group 1: 18 – 20 yrs and group 4: 41 -50 yrs). However because of the statistical insignificance of the KW test for males these values can only be taken as general indicators of an effect size increase compared to women. This would suggest that no firm conclusions can be drawn from these data, and certainly no practical or theoretical significance can be claimed.

Educational History

348 (82%) students had completed all of their previous education in the UK, 69 (16%) had received education both within the UK and elsewhere, and three (0.7%) had not previously received any education within the UK. Three students did not give an answer to this question. The number of students in each category demonstrating the different levels of anxiety is shown in Fig.11.

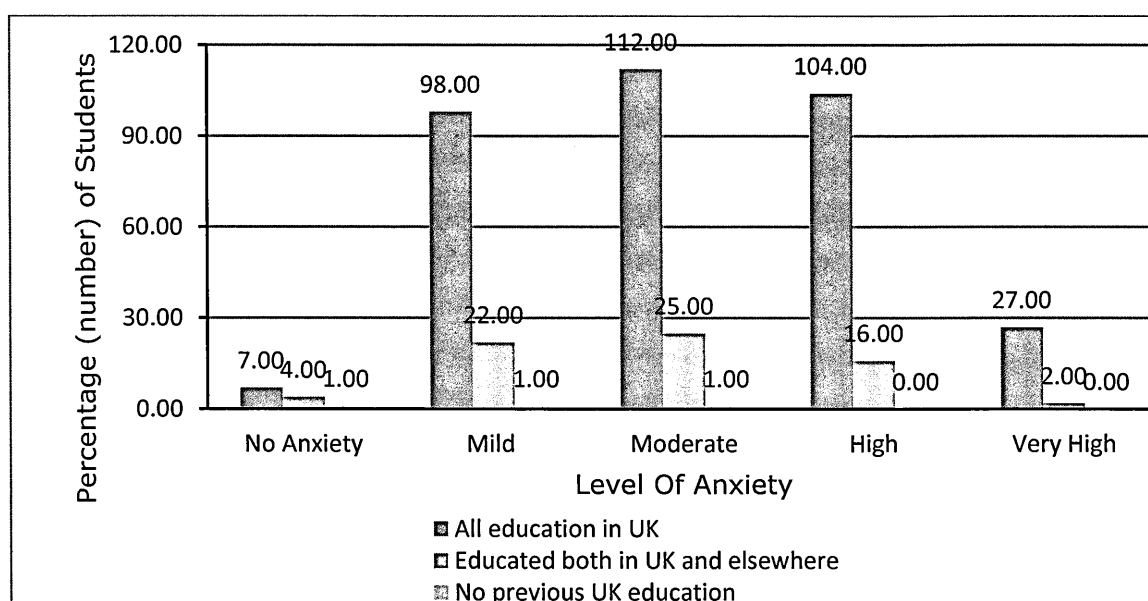


Fig. 11: Mathematics anxiety levels according to educational history

As the number of people educated outside of the UK was so small there was little value in conducting statistical analysis beyond descriptive statistics.

Highest Mathematics Qualification

Three students did not indicate their highest mathematics qualification and 17 gave an answer that was unclear, e.g. Grade 5 or 90%. Six students indicated their highest qualification as being GCSE grade D, E or F which is interesting in itself as the standard minimum entry criteria for the programme includes Mathematics GCSE grade C, or equivalent. A further two students claimed a Functional Skills Level 1 as their highest qualification which is again below the entry level for the programme. These eight students (1.9%) were grouped into one category, Qualifications below GCSE grade C. 57 students (13.5%) had Access Course qualifications, which are considered equivalent to a GCSE grade C, and a further 47 (11.1%) held Adult Numeracy Level 2 qualifications, which are also deemed equivalent to a GCSE grade C. Six students (1.4%) indicated a GCSE qualification, but did not indicate the grade. 171 (40.9%) had a GCSE grade C, 68 (16.1%) had GCSE grade B and 24 (5.7%) had A or A*. Seven students (1.4%) held an AS grade D qualification and 14 students (2.8%) held A-Level qualifications grades A – D. One student (0.2%) held a Baccalaureate qualification, but did not indicate at what level mathematics had been studied within this. The levels of anxiety demonstrated by students with these different mathematics qualifications are shown in Table 4.

In order to carry out a statistical analysis of these results, the qualifications were banded into two categories, GCSE or equivalent and Higher than GCSE. Those qualifications appearing to be below GCSE were recorded as

missing data because their equivalence could not be verified (e.g. grade F), and those reporting qualifications below GCSE Grade C were unreliable as this is a minimum entry qualification for access to the programme. A parametric test could not be conducted for the same reasons as above, so, as there were only two categories, a Mann-Whitney U test was utilised. This revealed no significant difference ($p = 0.186$) in the anxiety levels of those with GCSE compared to those with higher qualifications. This is surprising as it might be expected that those with higher level qualifications would be less anxious than those with lower level qualifications, but it is recognised that there were only 22 students in the higher category. Because of this low number, there seemed little value in further splitting the results by gender or age.

Table 4. Anxiety levels related to highest mathematics qualification

	Very High	High	Moderate	Mild	None
Qualifications below GCSE	3 (37.5%)	3 (37.5%)	2 (25%)	0 (0%)	0 (0%)
Access Course	12 (21.1%)	20 (35.1%)	17 (29.9%)	7 (12.3%)	1(1.8%)
Adult Numeracy Level 2	2 (4.3%)	20 (42.6%)	18 (38.3%)	7 (14.9%)	0 (0%)
GCSE – (No grade given)	0 (0%)	0 (0%)	3 (50%)	3 (50%)	0 (0%)
GCSE grade C	11 (6.4%)	50 (29.2%)	60 (35.1%)	48 (28.1%)	2 (1.2%)
GCSE Grade B	2 (2.9%)	16 (23.5%)	17 (25.0%)	29 (42.6%)	4 (5.9%)
GCSE grade A / A*	0 (0%)	6 (25.0%)	8 (33.3%)	10 (41.7%)	0 (0%)
AS Level	0 (0%)	1 (14.3%)	3 (42.9%)	3 (42.9%)	0 (0%)

A-Level	0 (0%)	0 (0%)	4 (28.6%)	7 (50.0%)	3 (21.4%)
Baccalaureate	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)

Students’ Feelings About Mathematics - Graphs

The third section of the questionnaire asked students to draw a line on a simple graph representing how their feelings about mathematics has altered during their lifespan; it is recognised that this is a very subjective account of the students’ recall of their feelings, but it helped indicate if students associated any particular life stages or specific events with a marked change in their feelings or attitude. On the graphs on which students plotted their feelings about mathematics across their lifespan, not surprisingly all except one of those who reported *no anxiety* plotted graphs that were all positive (e.g. see Fig. 12).

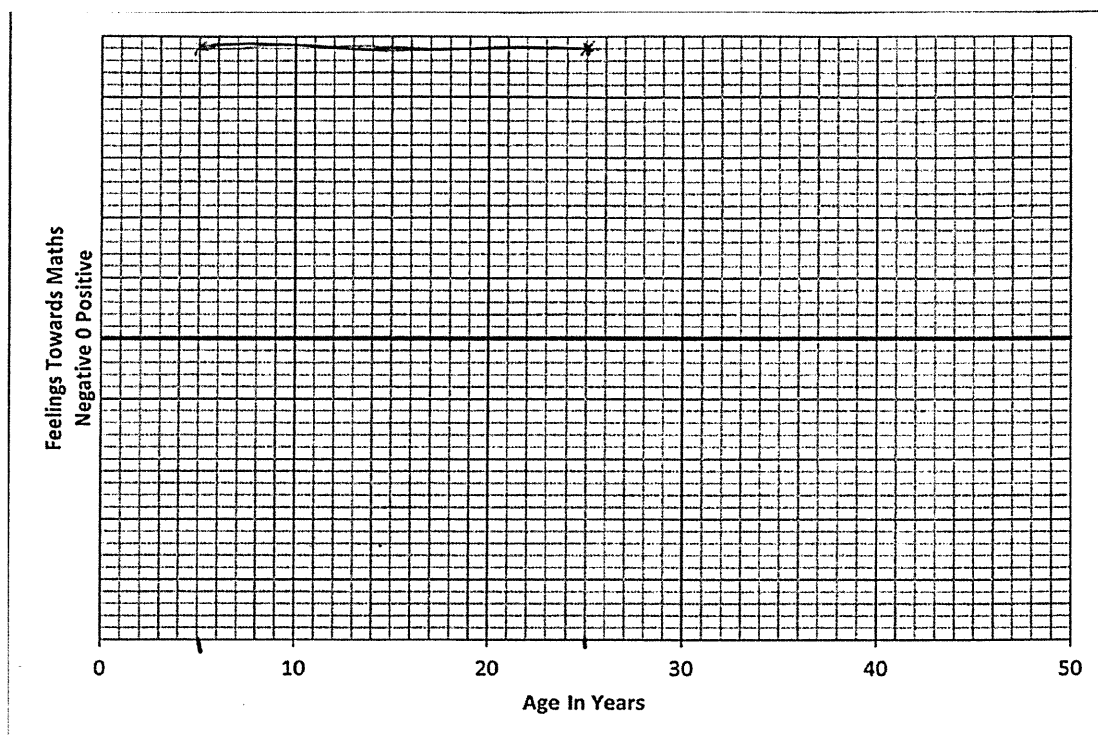


Fig.12: Typical graph of a student reporting no mathematics anxiety (Student 126)

The remaining student plotted a graph that was decreasingly negative until the age of 17 and then increasingly positive (see Fig.13).

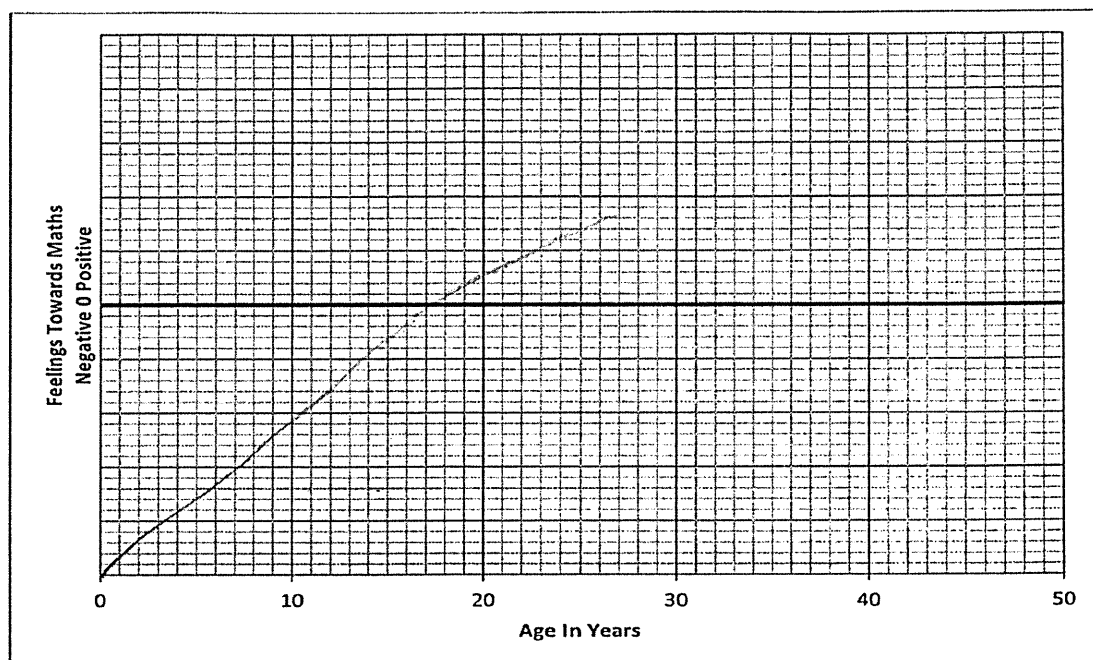


Fig.13: Graph of student reporting no mathematics anxiety (Student 185)

For those students reporting high or very high anxiety, the majority of the graphs showed negative feelings towards mathematics throughout the lifespan (see Fig. 14).

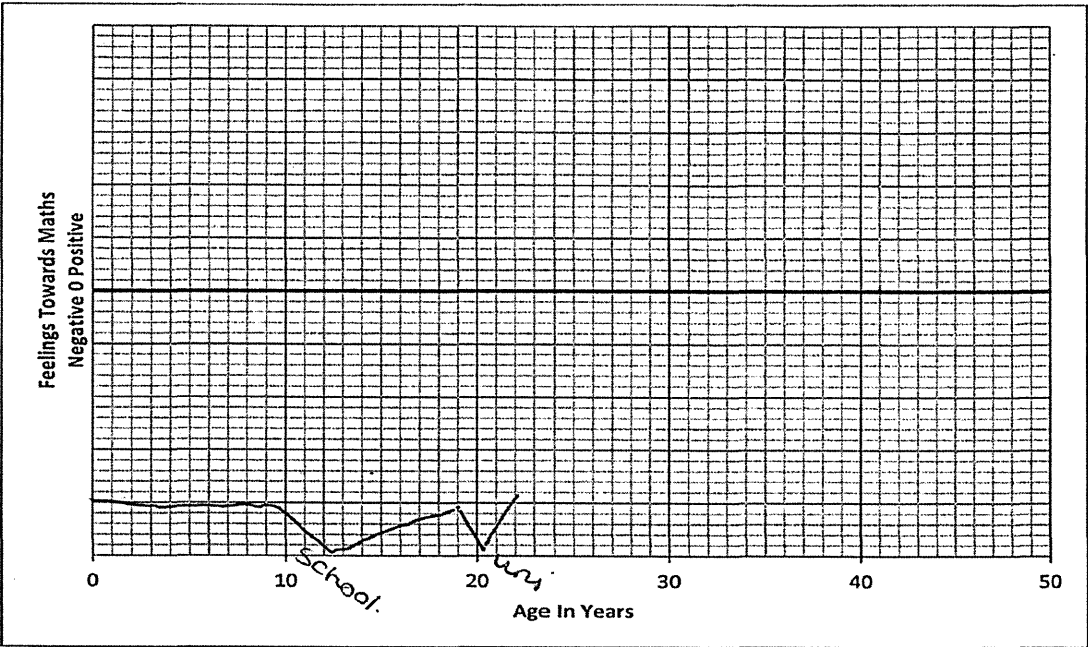


Fig.14: Typical graph of student reporting very high mathematics anxiety (Student 237)

Others showed fluctuations between positive and negative (see Fig.15).

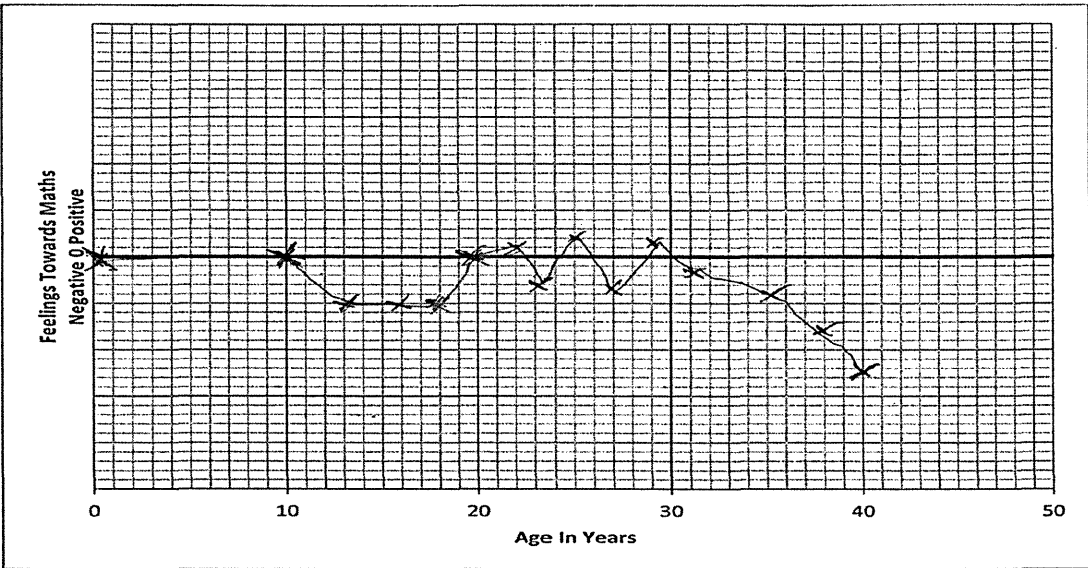


Fig.15: Graph of student reporting high mathematics anxiety (Student 418)

However, out of the total population of 423 students only seven individuals (1.7%) drew graphs indicating a sharp or sudden decrease in their feelings, (see Fig.16) which might indicate that a specific event was a significant contributory factor.

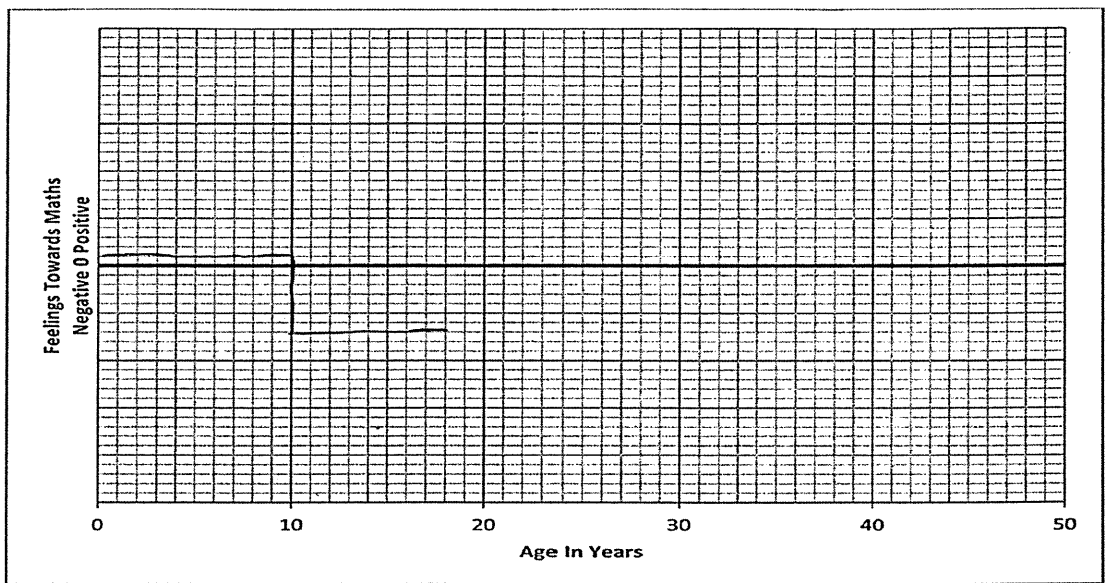


Fig. 16: Graph showing sharp decrease in feelings towards mathematics (Student 232)

These findings do not support the commonly held belief that *one off* bad experiences are *often* the cause of mathematics anxiety. Of the seven individuals who did show a severe decline, the age at which this occurred varied considerably. For one student it was at age 5 and two other students indicated that it was at age 10 that there was a severe decline in their feelings about mathematics. The remaining four were aged 13, 18, 22 and 38. The student who drew a marked decline at age 22 labelled this as *access course*, suggesting that they felt the access course contributed to their negative feelings about mathematics.

The majority of students who indicated a decline in their feelings at any point in their lifespan, indicated that although the change in feelings might be

extreme, for example from quite positive to very negative, it occurred over a period of time, usually three or more years.(see Fig.17).

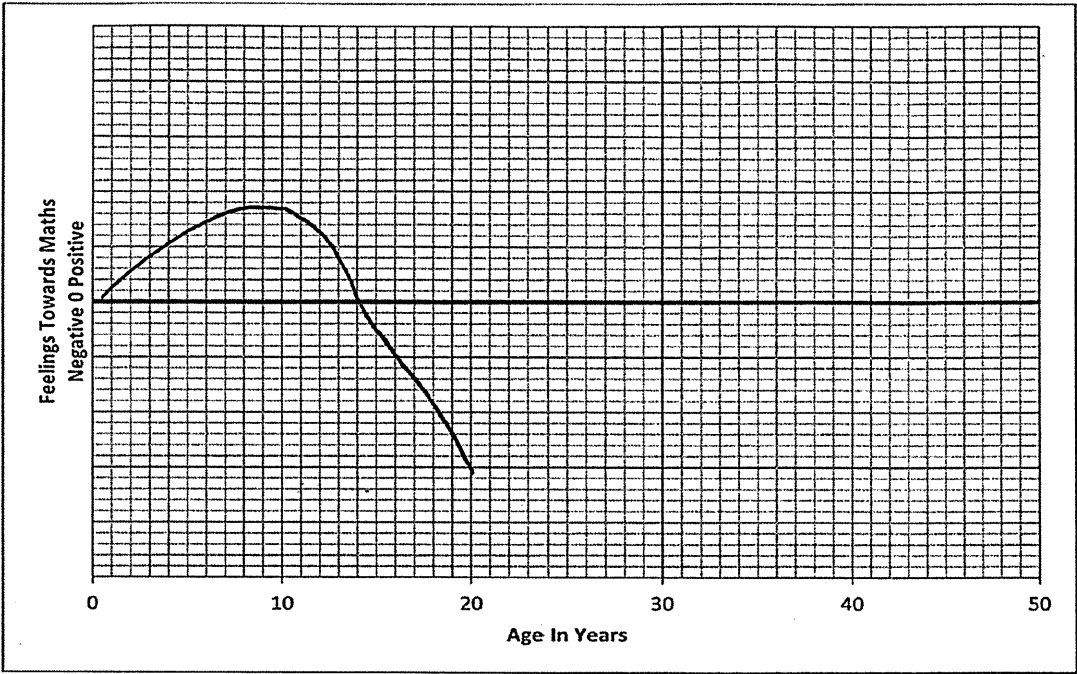


Fig. 17: Typical graph of a student indicating a decline in their feelings towards mathematics (Student 3)

Students’ Feelings About Mathematics - Comments

Students were asked to provide a word, phrase or sentence that summed up their feelings about mathematics. Not surprisingly, those who expressed *No Anxiety* provided positive and even enthusiastic comments about how they felt about mathematics. This group used words like *comfortable*, *confident* and *enjoyable*. Some students in this group commented that they *enjoy the challenge* of mathematics and one described it as *exciting*. Likewise the group that reported *Mild Anxiety* provided generally positive albeit more cautious comments. Again words like *comfortable* and *enjoyable* were used by some students in this group. Others used terms such as *OK*, *Alright* and *Good*. Some students in this group gave more detailed qualified responses

such as *it makes me feel slightly anxious, however I feel I can tackle it with some thought, ok but get nervous of tests and exams or confident once I know how to do it.*

For those in the group reporting *Moderate Anxiety* the comments start to become more negative. There are still some positive / neutral comments such as *alright, OK, not too bad* and *Bored (please don't take this offensively I just don't really enjoy it)*. However, there are substantially more negative and more detailed comments such as *worrying as I find it hard to remember, nervous, I go blank* and *I don't feel confident in mathematics and get very nervous when it comes to exams*. Several students in this group provided answers which suggested they were able to differentiate between different experiences related to mathematics. For example, *Depends what aspect? Fractions percentages and decimals are worst, some parts of maths I'm really good but struggle somewhat on other parts, when alone quite positive but very anxious when being watched / graded, I don't really enjoy maths, however I am capable of doing well and anxious and frustrated that a lot of the time I know how to do it but lack confidence.*

For those students reporting *High Anxiety*, their comments become much more negative. Words like *sick stressed, anxious* and *worried* are frequently used along with *nervous, apprehensive* and *confused*. Some students in this group stress that they *dislike* or *hate* mathematics, and others describe actual symptoms of anxiety such as *sweating, fast pulse and heart rate* and *sick to the stomach*. Again some students attempt to rationalise their feelings with one key factor appearing to be memory – *apprehensive*

because I may have forgotten how to complete some mathematical problems, nervous, find it difficult to grasp formulas -once grasped I forget easily and normal maths i.e. dividing, adding subtracting I'm ok with, however anything that needs memory i.e. formulas I struggle with. Another factor that clearly affected several students in this group was examination situations – confident until faced with a test, it makes me very nervous especially when having to take a maths exam and scared *only when an exam is involved.* Others explain *I feel I am ok with some aspects of maths but others make me panic i.e. long division and Maths is the bane of my life! Failed it 4 times at GCSE.* Only one student commented on any previous experience that had influenced their feelings about mathematics, *I feel unconfident due to a bad experience in junior school but I know that I have the ability to do maths (I passed maths GCSE).*

Not surprisingly, for those reporting *Very High Anxiety*, students generally offered very negative comments. Again students in this group used words like *stressed, anxious and worried* as well as *scared, terrified and panic.* These students also describe feeling *stupid, silly and thick.* Some again allude to issues with memory, *I have a complete block when it comes to maths. I can never retain the information* and others claim to feel *depressed, afraid of punishment and a failure.* One student did suggest that she suspected that her feelings about mathematics actually affected her ability – *I absolutely hate maths. I think that because I dread it so much that it affects my ability to learn.*

The comments that students made were unsurprising in the sense that those with higher levels of anxiety offered more negative comments, but they were helpful in that they added some context to the associated anxiety score and helped to understand that anxiety from the student's perspective. Some of the themes that emerged were identified as those to be explored further in the Interview phase. These included *physical symptoms, whether students felt that their feelings about mathematics affect their ability and whether exams or assessments cause any particular problems.*

So a survey of 423 student nurses and an analysis of the results has shown that 68.1% reported moderate or higher levels of mathematics anxiety. There did appear to be a significant difference in mathematics anxiety levels between genders, although a subsequent test of effect size showed the difference to be only a small effect. Likewise, there appeared to be a significant difference between age groups but only for females and again the effect size was small. Within the cohort studied, there were insufficient students who had been educated outside of the UK to determine if this was a significant factor related to their mathematics anxiety, and there appeared to be no significant difference in the levels of mathematics anxiety between those students with a GCSE mathematics qualification or equivalent and those with higher level mathematics qualifications. When students were asked to plot a graph of their feelings about mathematics across their lifespan, unsurprisingly those who reported little or no mathematics anxiety generally plotted positive feelings, whilst those who reported high or very high levels of mathematics anxiety tended to plot negative feelings on their

graphs. The comments that students made regarding their feelings about mathematics were also unsurprising in that those who reported higher levels of mathematics anxiety made the most negative comments. However, these comments were useful in that a number of themes emerged that formed the basis of further exploration in the interview stage of the study.

Chapter 6: The Main Study – Interview Phase

The entire cohort of students were e-mailed, thanking them for taking part in the survey phase and asking if any of those who had been identified as having high or very high mathematics anxiety would be willing to be interviewed about their previous experiences related to numeracy or mathematics. Eleven students initially indicated a willingness to take part, and nine were eventually interviewed. Of the remaining two, one withdrew before the interview and the other did not attend. The interviews were intended to capture the students' *stories* related to mathematics but it was recognised that some might not have a story to tell or that they might need to be asked open questions to help structure the interview. Therefore, whilst there were no set questions, a list of potential questions and topics for discussion was developed (see Appendix 8) In fact, only two students had *stories* to tell in the way I had anticipated, but the other seven were all very willing to talk about their past experiences and their feelings about mathematics. The list of topics and potential questions was therefore very useful in structuring these discussions. The interviews took between thirty five and eighty five minutes. The list of topics and questions were modified between interviews as early themes started to emerge. The interviews were transcribed and then analysed for emergent themes.

Initially I felt completely swamped by all the information the students had given. When I started to break it down there was so much and it seemed that everything they had said was important. I had huge tables of information and dozens of themes seemed to be emerging. I recognised that I would not be able to use all the data I had gathered, so eventually I narrowed it down to

the themes that there had been the most discussion about, and which had appeared to be most important to the students.

The key themes that emerged were:-

Language related to mathematics,

Students' inherited legacy of mathematics

Anxieties related to mathematics

Mathematics in the Practice Environment

What students found helpful

The Students

The students have been allocated pseudonyms to protect their confidentiality:-

- a) Ann is female, between 21 and 30 years of age, and has received all of her education in the UK. She achieved a GCSE grade C in Mathematics.
- b) Barbara is female, between 21 and 30 years of age, and has received all of her education in the UK. She passed Mathematics as part of an Access course.
- c) Charlie is male, between 31 and 40 years of age, and has received all of his education in the UK. He completed a Key Skills Level 2 qualification in Mathematics.

- d) Dee is female, between 31 and 40 years of age, and has received her education partly in the UK and partly in Europe and America. She achieved a GCSE grade A* in Mathematics.
- e) Elsa is female, between 31 and 40 years of age, and has received all of her education in the UK. She achieved a Key Skills Level 2 qualification in Mathematics.
- f) Fiona is female, between 31 and 40 years of age, and has received all her education in the UK. She passed Mathematics as part of an Access course.
- g) Gayle is female, between 31 and 40 years of age, and has received her education partly in the UK and partly in Europe. She achieved an Advanced Level qualification in Mathematics (equivalent to a UK A-Level), but states that this was a standard requirement in her home country.
- h) Helen is female, between 41 and 50 years of age, and has received all of her education in the UK. She achieved a CSE grade 1 in Mathematics.
- i) Ina is female, between 18 and 21 years of age, and has received her education partly in the UK and partly in Africa. She achieved a GCSE grade C in Mathematics.

Demographics

Of the nine students who were interviewed, there were eight females and one male. One student was in the 18-21 age category, two were between 21

and 30 years old, five were 31 - 40 and one was between 41 and 50. There were no students from the 51+ age group, but then there were only two students from this age category in the cohort and both reported only mild levels of mathematics anxiety. Six students had received all of their education in the UK and three had received their education partly in the UK and partly abroad in Europe, Africa and America. Two students had achieved a GCSE grade C as their highest mathematics qualification, one a GCSE grade A* and one a CSE Grade 1. Two had completed access courses and two had completed Key Skills Level 2 Numeracy. One student had achieved the equivalent of A-Level mathematics but this was compulsory in her home country.

Language Related to Mathematics

During the explanation and briefing about the interviews, the students were told that I was interested in their anxiety related to numeracy. The term numeracy was specifically used at this point and the first question asked related to the students' earliest memories of using numbers. Seven of the students used the word *maths* or, in one case, *mathematics* in response to this question:-

I just remember having maths lessons ... just basics – addition, subtraction and times tables. (Ann)

I remember doing maths at infant school. (Fiona)

The remaining two students reported memories related to counting, using an abacus, using counters and using play money. Throughout the interviews all students frequently used the term *maths* and all talked about specific aspects

of mathematics such as addition, multiplication, fractions, decimal points, times tables, logarithms, geometry and algebra. Four students did use the term numeracy on one or more occasion, but they all appeared to use it interchangeably with the term *maths*:-

I liked the maths in the numeracy exam this time. (Dee)

Two students used the term *arithmetic*, and in both cases this related very specifically to mental arithmetic.

One student appeared confused about the terminology related to multiplication and thought that the term *timesing* was something different to multiplication:-

I'm ok with timesing but I can't do multiplying... are they the same thing? I thought timesing was tables and multiplying was harder, you know, bigger numbers. (Ina)

The Students' Inherited Legacy of Mathematics

Earliest Memories of Using Numbers and Experiencing Mathematics Anxiety. All of the students were asked about their earliest memories of using numbers. The earliest memories they could recall ranged from age 4 to the 4th year at primary school (about age 9). All students responded that their earliest memories related to numbers were happy ones, and generally included counting, addition, subtraction and multiplication tables (often referred to as *times tables* by the students):-

I used to count sweets and things like that. (Charlie)

The earliest I can recall is the abacus... I liked it more as a plaything.
(Elsa)

I remember doing maths at Infant school and being quite comfortable with it there. (Fiona)

At age 6 I remember I was quite good at maths... I enjoyed it then.
(Gayle)

I actually liked playing with maths. I did enjoy it... enjoyed competing with the lads. I found it challenging and I liked that challenge. (Helen)

The age at which students recalled starting to feel anxious about numeracy or mathematics ranged from 5 to 16 years old. Two of the students attributed the onset of these feelings to the teacher they had at the time:-

We had a really horrible teacher... if you got a question wrong she made you stand up in front of the class for the whole lesson. (Ann)

Five of the students attributed the onset of their anxiety to a point at which they recognised they were not doing well in the subject, were falling behind their peers or could not understand what they were being taught:-

I was not doing particularly well and then I got knocked down a group, away from my friends. (Charlie)

I just slipped ... slipped further and further behind. (Fiona)

I just didn't understand how to do it; I panicked and then just avoided it as much as I could... from then on I never liked maths again. (Ina)

One student reported that she had been quite comfortable with mathematics throughout school although it had been quite a challenge for her. She had wanted to go into the “O-Level group” but her school had not allowed it as she “wasn’t good enough” despite that fact that she felt she was doing well in the subject and that she would cope with that level. She attributed her subsequent mathematics anxiety to this refusal.

I didn’t manage to get into the O-Level. I went to see the teacher and said could I just try the higher level maths but they said because I hadn’t got the grades I couldn’t do it. I think I started to cower back then and think I don’t really know that. (Helen)

The remaining student identified the start of Advanced Level study as the time when she started experiencing anxiety related to mathematics. This was because she was required to do mental arithmetic for the first time. This had not been required before (overseas education) and was something she felt she had never been able to master. She reported being quite confident in her mathematics if it were on paper but, in any mathematics assessment, panicked in case mental arithmetic was required, even if she had been assured that it would not be.

Parental and Family Attitudes to Mathematics. - Students were asked about their family’s attitude to mathematics and in particular what their parents’ involvement in their mathematics education had been. Students generally recalled encouragement from their parents rather than specific help with their mathematics, although three students had had additional mathematics tuition arranged by their parents.

My mum bought me books and stuff like that... she used to have to bribe me to do maths, it was like well if you get an answer right, I'll give you a gel pen. (Ann)

My mum paid some-one to come to the house and help me. (Barbara)

How I was doing in maths wasn't mentioned as such – my mum struggles with maths too. (Charlie)

They (my parents) didn't really understand the maths that I was doing and if they asked I just said that I was ok. (Fiona)

The student who had wanted to go into an O-Level mathematics group but had not been allowed reported that:-

I remember complaining to my mum and my mum saying 'the teachers will know whether you're going to fit in or whatever. If you're going to struggle and get a low mark then you're probably better to continue with the CSE'. I do feel it stems from that. (Helen)

Relationships with Mathematics Teachers - Two students reported specific negative experiences, each with one particular mathematics teacher to which they entirely attributed their subsequent anxieties related to mathematics. Of these one had been physically punished and verbally abused by a mathematics teacher many years previously which had had a profound impact on her subsequent ability to engage with the subject despite having later teachers who she described as "lovely" and whom she "held in high regard" (Elsa). The other student described her experience as follows:-

She was really nasty, loads of people complained about her. If she asked you a question she used to say "Come on quick, you should know this", and if you didn't know she'd say, "Well, you need to learn!" ... when I had that teacher I didn't want to know maths after. (Ann)

The other seven students did not have any specific negative incidents but reported that their teachers were overworked, unable to cope or just not interested in them.

I didn't really get any help. It wasn't a great school and we had substitutes (teachers) all the time. The maths was really rushed and if you didn't understand it I don't think they were too fussed about helping you. (Barbara)

It was at the time there were a lot of teaching strikes and lessons were cancelled. The kids were what you'd call naughty kids, the teacher couldn't handle them. He was only a young maths teacher... you just didn't learn anything, even if you wanted to. (Charlie)

It was a badly run school, there were no resources. They weren't horrible teachers but they were stressed. I think if you were naturally bright you did ok but if you weren't they just left you to it. There was no interest at all. (Fiona)

Anxieties Related to Mathematics

Anxiety Symptoms Experienced by Students - All students reported one or more symptoms of anxiety. These included an inability to stop crying, an inability to sleep, nausea, vomiting, sweaty palms, sweating generally,

heartburn, tightening of the chest, a rapid heartbeat and palpitations, feeling hot, going red and frequently needing the toilet. Some students also reported feelings of dread, overwhelming panic and a desire to run away:-

Give me maths and I like ... I sweat! It's terrible. (Charlie)

All the students reported that these symptoms were most acutely associated with mathematics examinations or assessments, although seven reported that they may have milder versions of their symptoms in mathematics lessons, tutorials or even when trying to learn or revise mathematics on their own:-

Even just getting my books out to try and revise, my heart starts racing, I go all hot and sweaty and I feel sick. (Ina)

Mathematics Anxiety and Mathematics Ability. All students must have achieved a GCSE Grade C or equivalent in order to access the course, so all have demonstrated some mathematics ability. However they were asked what they thought of their mathematics ability. Interestingly some of them clearly recognised that they were actually quite good at mathematics and yet still felt highly anxious about it:-

That's the weird thing; I'm not bad at maths. I don't really understand why I've got it (anxiety) myself, because it is true that I haven't got bad results. (Dee)

I wouldn't say that I'm not good at maths, I have to practise it and if I don't I forget it. It doesn't come to me naturally and that's what makes me anxious about it. (Helen)

Other students did consider they had poor mathematics ability, despite evidence of previous successes in the subject.

It affects my mindset and the fact that I don't believe I'm capable of doing it ... I don't have any self-confidence with maths at all. (Fiona)

I'm just rubbish at maths, always have been, always will be! (Ina)

It was evident that some of these students anticipated failure at some point, even though evidence of their past successes did not support this conclusion.

The Aspects of Mathematics that Cause Students Anxiety - When asked about what aspects of mathematics or numeracy caused them anxiety, all students referred in some way to a sense of being faced with something they could not do, or thought they would not be able to do:-

The thing that always throws me is fractions ... I just can't do them! ... It is such a worry that maths could ruin my life basically... if I fail this course. (Charlie)

I think it is the unknown world of maths that I just don't want to venture into in case I can't do it. (Dee)

I'm terrified that I'm going to kill somebody... because of my maths. (Fiona)

All students reported increased anxiety related to examinations or assessments. Two of the students reported that they would get equally anxious for other examinations, but seven reported that their symptoms were

more severe in relation to mathematics than they would be for any other type of examination or assessment.

I don't love exams in general but maths is much much worse. (Barbara)

If I had to do a comprehension exam, I wouldn't be worried about that... but maths, I feel really highly stressed about it, very doubtful of my ability to do it. (Fiona)

Mathematics in the Practice Environment.

By the time the interviews were conducted all of the students had been out on their first clinical placement in practice. They were asked about the mathematics that they were required to do on their clinical placements and how they felt about it. Generally they reported lower levels of concern regarding what would be required of them in practice:-

I'm fine with it on the wards. (Barbara)

It doesn't bother me so much in practice. (Charlie)

Four students commented specifically on their lower levels of anxiety being related to their understanding that they would work with other people and therefore would not be undertaking calculations on their own:-

I'm confident (on placement) because we work together and we check – like a buddy system. I enjoy working as part of a team and checking each other's answers are right. (Elsa)

Mentors in practice appeared to have a key role in reducing the students' anxiety levels in relation to medication calculations:-

I told my mentor I was really scared of maths so every now and then she'd throw a maths equation in... when we had 5 minutes she would take me into the office and like come on let's do some maths. I am getting more confident with it now. I'm one of those people who's hands on, I'd rather learn by doing it. (Ann)

When doing drug calcs, my mentor would go through it with me and help me with it. (Barbara)

The opportunity to practise medication calculations on a regular or even frequent basis appeared to be an important factor for some students.

I did it (medication calculations) a lot on placement cos my ward had constant drug rounds so I had to do it every day. I learnt but it took me a while. (Barbara)

I did a lot (of medication calculations) on placement. After the first day I knew that 2 x 500mg was a gram – that's in my head now. When I practise like that it stays, but if I don't do it for a while when I go back to it its like oh, how did I do that? (Charlie)

Some of the students reported that they found the practice areas less stressful than the university environment:-

I'm ok with it then (in practice) because I don't feel like we are under a really stressful situation. In uni you only get two attempts. If you fail you are off the course, whereas in placement if I get it wrong I know I've got my mentor there to show me (Barbara)

In relation to the calculations she had done in practice, she also commented:-

I wasn't always right but I wasn't far off (Barbara)

When asked how she felt she would cope with medication calculations when she was a qualified nurse, she added:-

I'll be ok then because I'll use a calculator. On placement we'd work it out first and then use a calculator to check it. (Barbara)

Other students were clearly concerned about the impact their actions could potentially have in the practice environment:-

I don't trust myself in practice. I know that $6 + 7$ is 13 but I'll check it on my hands (fingers) because I wanna make sure, especially with drugs and stuff, I'd wanna check it all the more. Thinking someone's relying on my maths for their lives, then I don't want to give them the wrong thing (Dee)

I'm worried because I feel that somebody is relying on me to get it right (Helen)

What Students Found Helpful

The students were asked what they found useful in helping them to develop more confidence in their numeracy skills, and what in particular a support department might be able to do to help. Some students were not sure that there was anything that would help;

I don't know. I think it is just how a person is. I don't think you can really change it. I don't think I'll ever be in a position where I feel confident about it. (Ann)

I don't know what you can do for confidence. That has to be down to me (Charlie)

I think I just have to help myself (Elsa)

However, all the students focussed immediately on assessments, with five students advocating the availability of practise papers:-

More practise papers would help. (Fiona)

On-line practise papers (Helen)

In particular, students felt that regularly completing practise papers helped with preparing for assessments;

Regularly doing practise papers every night (Ann)

I never look at practise papers on the day. I don't start revision too early either. I leave it until two weeks before and then do it every day (Barbara)

It helps for me to keep practising (Helen)

However, some of the students found that whilst this helped them to pass the assessment, they did not retain what they had learnt, so was clearly not an effective learning strategy;

I don't remember the stuff a few weeks down the line (Barbara)

As long as I'm doing it it's ok, but if I don't do it for a while I can't remember how to do it (Charlie)

Elsa's response in relation to practise papers was;

I find myself doing the questions, checking the answers and memorising it... if I come to the exam and that question is on the paper, I know I won't have to spend so much time obsessing. (Elsa)

This response suggested that she was using practise papers to try and rote learn answers to questions which might come up on the paper rather than practising the methods she had been taught. Whilst it could be argued that if there were sufficient repetition of questions this could be an effective strategy for passing an examination, it is an extremely ineffective way of developing the mathematical skills that the student needs to be able to transfer into the practice environment.

One thing that three students identified as a particular factor related to examinations was time;

If you left me on my own for an hour (assessments are 30 minutes) I'd be ok and work my way through it really slowly (Ann)

However, Ann subsequently went on to say that she had finished well before the end of the examination and this in itself had been problematic;

I'm thinking I've done this all wrong, so I start again. I'm coming up with the same answer but I keep doing this until the time's finished (Ann)

Elsa says a similar thing;

I need more time in examinations, although I do waste time checking over and over again (Elsa)

If this is the case then more time could potentially create more anxiety. One student specifically identified the clock in the examination room as adding to his anxiety;

During the maths exam, that massive clock that I sat right in front of wasn't good. Oh my goodness, it was everywhere, one in front of me, one to this side of me, one to that side of me... just tell me when we're running out of time, don't put that clock in front of me. I was anxious enough. (Charlie)

Seven students claimed that they found small group tutorials and / or one-to-one support helpful, either in relation to preparing for examinations or when thinking about what they found most helpful in developing their numeracy skills in general;

The one-to-one and drop-in sessions are helpful. (Charlie)

I can't follow it in a bigger class (Dee)

I can only do it (learn mathematics) in a one-to-one situation. (Gayle).

The reasons that students gave for their preference of one-to-one tutorials were as follows. They could work at their own pace;

I have to go at my own speed. If the tutor goes too slow, going over stuff I know, then I get bored and start thinking about other stuff. If they go too fast, I get lost and can't catch up again (Ina)

They could use their own preferred methods;

Showing me another way of doing something isn't helpful. I need to do it my own way. The tutor needs to do it the way I know. (Dee)

They could ask questions without being embarrassed;

I liked the tutorials – there was only a few of us and I could ask questions (Dee)

One to one tutorials are helpful, cos even with my friends I feel a little bit embarrassed. (Fiona)

It was easier to identify exactly where they were going wrong;

I think one-to-one sessions are good because you can then try and work out where you are going wrong. (Dee)

The student whose mum had paid for private tuition said of the tutor;

She was really nice, she took things really slow with me cos it took me a while to understand things and if she knew I'd had enough or if I was getting too stressed, she'd leave. She would recognise when my head wouldn't let me take anything in (Barbara)

This suggests that for Barbara, it was not just a case of being able to ask questions and going at her own pace, but it was also important that the tutor was sensitive to her feelings and reactions, and knew when to stop.

The university uses an on-line virtual learning environment called Moodle and the department has created a substantial amount of numeracy support material that is available to students. Six students commented on this when asked what they found helpful but they were split in their opinions related to it. Four reported that they found it helpful:-

I like the on-line thing you've got – that helped quite a bit. (Barbara)

I like it (Moodle)... you get the opportunity to practise and start again. (Elsa)

The materials and tests on Moodle are very good (Gayle)

Practising on-line is really good. (Helen).

However two students claimed not to like it at all, one because he did not like using a computer screen:-

I don't like reading it on the screen...I prefer face to face and writing it down. (Charlie)

And the other because she didn't understand the information that was available:-

The Moodle stuff is useless, it doesn't make any sense ... you need to understand maths to be able to use it, so if you can use it you don't need it. (Ina)

Students found other learning resources such as medication calculation texts and other on-line resources useful to a limited extent. However it should be noted that these students were still in the early stages of their programme

and it is anticipated that they would start to find these more valuable as they progressed through the programme. Two students did identify relaxation techniques which they felt were helpful in managing their anxiety prior to or during mathematics assessments. One would go swimming prior to an assessment as she found this helpful and the other would employ a breathing technique that she had been taught to help her manage her anxiety during mathematics examinations.

Four students reported that being allowed to use calculators would help to reduce their anxiety particularly if they were allowed to use it within an examination:-

I'm happier with a calculator, but I would still roughly work it out first
(Barbara)

I am comfortable if I have a calculator to work it out. I'd do it more than once to make sure the figure was correct. (Charlie)

I'm better with a calculator... because I make silly mistakes adding... just cos I get flustered I suppose. (Fiona)

One student reported that she had used a calculator in practice and found it to be helpful in checking her answers when doing calculations in the clinical area. She did seem to be under the impression that nurses should not use calculators in practice, although this is not the case;

I know nurses shouldn't do it but they do all use calculators as well.
We'd work it out first then use a calculator to check it. (Barbara)

Another claimed that she would rely on a calculator rather than her own skills in practice;

I would still double / triple check it but I would rely on it (a calculator) more in practice. (Dee)

Other things that students said they found useful in practice included keeping a notebook to write down formulas and notes on how to calculate medication doses. Always writing down medication calculations in the practice areas rather than trying to work them out in their head was also reported as helpful.

So, in summary, nine students took part in in-depth, semi-structured narrative interviews. Whilst most students did not have stories to tell in quite the way I had anticipated, they were still willing and able to provide very detailed information about their experiences related to mathematics. The interviews were audio-recorded, transcribed and analysed for emergent themes. Many themes emerged but the ones that appeared most important to the students were the language related to mathematics, the students' inherited legacy of mathematics, the students' anxieties related to mathematics, mathematics in the practice environment and what students found helpful. These themes were the ones that were discussed most prolifically and are the ones that will be discussed in more depth within the context of the literature in Chapter 7.

Chapter 7: Discussion of Findings

There were 518 students in the cohort studied. Of those who participated in the study ($n = 423$), 68.1% reported moderate, high or very high anxiety related to mathematics. This was considerably higher than anticipated although it is only slightly higher than the results gained by Tariq (2002) who found that 42 – 63% of first year bioscience students in one university encountered difficulty with a diagnostic test of their basic numeracy skills. However, Tariq was measuring difficulty with a test, not levels of anxiety.

Mackenzie (2002) undertook a study of the level of mathematics anxiety amongst the students attending the HE College in which she was working, where 25% admitted to some concern and avoidance of mathematics learning. Mackenzie notes that this figure is consistent with other studies such as those carried out by Betz (1978) and Hembree (1990). Mackenzie acknowledges that this figure is likely to be an under-representation of actual levels of mathematics anxiety, but she bases this on the assumption that students who were interested in and comfortable with mathematics were those most likely to return the questionnaire (the return rate was 42%). Whilst this could be true there is absolutely no evidence to support this assumption. Experience suggests that it may be the case that those concerned about their mathematics ability are more likely to respond in the hope that responding may precipitate help and support with addressing their concerns. It should also be noted that for the survey stage of this study, the students were in the first two weeks of their programme, so it is likely that their anxiety levels might be higher at this stage.

The AMAS section of the data collection tool was based on that produced by Hopko et al (2003). It should be noted that with the possible exception of the final statement “starting a new subject area in maths” all of the statements reflect technical processes related to mathematics and could therefore be aligned to the behaviourist approach to the teaching of mathematics. It could be argued that scenarios that reflect this approach are much more likely to induce a feeling of anxiety than real-world examples might (Anderton and Wright 2012). One of the statements was changed to reflect a real world example but in retrospect it would have been interesting to include several such statements and compare whether the levels of anxiety reported by the students differed between the two types of scenarios.

Gender

It does appear to be the case that, within this group, anxiety levels are higher in females, although it should be noted that there are substantially more women (90%) in the group. The results of an independent samples t-test showed that there was a statistically significant difference in scores for males ($m = 12.07$, $sd = 8.37$) and females ($m = 14.89$, $sd = 8.68$) $p = 0.048$, two-tailed. However, calculation of the effect size showed that this difference ($\eta^2 = 0.009$) was only a “small effect” (Cohen 1988). Nonetheless it supports the claims by Geist (2010) that females are most at risk of mathematics anxiety, and Sabin (2001) who maintains that there is a gender difference, which is important in a predominantly female discipline such as nursing. However, based on this study this appears to be true only to a modest degree. In other words, although there is a statistical difference, in reality it is not very

important in determining what interventions or support might need to be provided.

The students that were interviewed generally did not comment on any perceived gender issues in relation to their own experiences. When asked whether boys were treated any differently to girls in mathematics classes, most students did not recall this being the case, although one student did feel there was a distinct gender difference;

I don't think they outwardly said it, but I think they pushed the boys more than the girls. If the boys showed ability, they'd have made sure they got into O-Level (Helen)

It should be noted that Helen was clearly aggrieved about not being permitted to be in the O-Level group herself, but she did feel she had been treated differently to the boys. Of course, the fact that other students did not perceive any gender differences does not mean that they did not exist. It could well be the case that the gender discourse had become so internalised that to the girls it seemed the natural order of things and they therefore did not see the bias. However, for whatever reasons, the students in this study did not perceive gender to be a significant factor in their own personal mathematics anxiety.

Age

In the survey stage, a Kruskal-Wallis test revealed a statistically significant difference in anxiety scores across the five different age groups (18 – 20 yrs, 21 – 30 yrs, 31 – 40 yrs, 41 – 50 yrs and 51+ yrs.). However, when the data were further split according to gender there was only a statistically significant

difference between age groups amongst females. A subsequent test of effect size revealed only a small effect. The lack of a significant difference between age groups amongst the males is almost certainly due to the small sample size. As a result, no firm conclusions can be drawn from these data, and certainly no practical or theoretical significance can be claimed. The literature related to age focuses more on the age at which mathematics anxiety tends to start rather than whether it is particularly prevalent in any particular age group. It is therefore not possible to draw any useful conclusions from this study about age as a factor in mathematics anxiety.

Educational History

The results of the survey showed that only 0.7% of the students had not previously received any education in the UK and only 16% had received some of their education outside of the UK. As the number of people educated outside of the UK was small there was little value in conducting statistical analysis on the data beyond descriptive statistics. Three of the students interviewed had received part of their education outside of the UK, one in Europe, one in both Europe and America and one in Africa. Dee, who was partly educated in Europe and America, did not feel that this had any impact on her anxieties relating to mathematics, but Gayle, who was partly educated in Europe, felt it was the move to the UK that had triggered her anxieties. This was because she felt there was an emphasis on mental arithmetic in the UK which she had not previously encountered. She felt that mental calculation was her weakest point and blamed the fact that she had not been taught this in school. She had achieved the equivalent of an A-Level in mathematics in her own country, which she says was compulsory,

and had not had any real anxieties about mathematics before moving to the UK, so it seemed that her anxieties were more to do with being unsure what would be expected of her on the nursing programme than the more typical mathematics anxiety experienced by other students. For the remainder of the students who were interviewed and for those in the survey stage, their educational history did not appear to be a significant factor in their mathematics anxiety.

Highest Mathematics Qualification

In the survey stage of the study there was clearly some confusion for some students about their highest mathematics qualification. Eight students (1.9%) gave qualifications that were below the GCSE Grade C or equivalent that is a minimum requirement for access to the programme. Of course it is possible that a small number of students *slipped through the net* but this is unlikely as applications are vetted by the Universities and Colleges Admissions Service (UCAS) as well as being processed through the university's admissions systems. It is possible that students gained qualifications, for example as part of an access programme, that they did not recognise as being equivalent to a GCSE Grade C or above. In order to carry out a statistical analysis of these results, the qualifications were banded into two categories, *GCSE or equivalent* and *Higher than GCSE*. A Mann-Whitney U test revealed no significant difference in the anxiety levels of those with GCSE compared to those with higher qualifications. This is surprising as it might be expected that those with higher level qualifications would be less anxious, but it is recognised that there were only 22 students in the higher category.

Again nothing could be found in the literature related to differences in mathematics anxiety according to highest mathematics qualification.

However, studies by Hutton (1998b) and Macdonald et al (2013) have shown that GCSE mathematics qualifications are not particularly useful in indicating a student's numeracy ability and this study suggests they are not a useful indicator of a student's confidence in their numeracy skills either. One could therefore question why we continue to require this qualification as part of our entry criteria and whether the pre-entry numeracy tests that already form part of the admissions process would be a better indicator of a student's ability to cope with the numeracy requirements of the programme.

The Language of Mathematics

There are many terms associated with Mathematics, e.g. Numeracy, Numerosity, Mathematical Literacy, Numerical Literacy and Arithmetic, which are often used interchangeably with the terms Mathematics or Maths and which can therefore cause confusion. The fact that one mathematical term is often used to define another, e.g. *numeracy is the ability to use mathematics in everyday life*, may go some way to explaining the tendency by many people to use the terms interchangeably, and of course, there is a degree of overlap.

The skills that nurses need are numeracy skills and in a nursing context, numeracy is defined as knowing what numbers mean and how they relate to each other, as well as the four basic arithmetic functions of addition, subtraction, multiplication and division. Coben (2000) explains that to be numerate means that as well as being competent; one also needs to be

confident and comfortable with one's judgements. A nurse needs to add, subtract, multiply and divide and do basic equations, not only to calculate medication, but also to perform many practice-related tasks such as monitoring fluid balance, so these are the skills in which nurse educators are trying to develop not only competence, but also confidence amongst student nurses.

However, it has become very clear that students see these skills as mathematics and it is easy to understand why. They studied *maths* at school, they were required to have *maths* qualifications to access their programme of study and, without exception in the students that were interviewed, it was *maths* that they reported that they were anxious about. This is supported by the National Numeracy Organisation (2013 np) who argue that for many adults the relationship between numeracy and mathematics is problematic because they “naturally equate the word ‘mathematics’ with their experience of lessons which many describe as ‘boring’ or ‘irrelevant’ ”. If individuals perceive the mathematics they did at school in this way, it is highly likely that they were taught using an absolutist approach. Ernest (1991) has explained that the absolutist view of mathematics as objective, logical, timeless and culture-free means that for many the subject seems remote and inhuman, very cold and highly technical, so it is understandable that it may be described as boring and irrelevant. The National Numeracy Organisation (2013 np) goes on to explain that some people feel that all the time spent in mathematics lessons did little to help them become numerate, and argue that many adults can be classified as *innumerate* even after many years of compulsory schooling.

It was clear that the relationship between numeracy and mathematics was not fully understood by the students that were interviewed. When specifically asked a question about numeracy, seven of the students used the word *maths* or *mathematics* in their response. Ann recalled early mathematics lessons covering what she described as the basics, i.e. addition, subtraction and multiplication tables. These responses are understandable as the lessons we received at school were called *mathematics* or *maths* even when, as Ann has described, the content was simply arithmetic. Throughout the interviews all students frequently used the term *maths* and all talked about specific aspects of mathematics such as addition, multiplication, fractions, decimal points, times tables, logarithms, geometry and algebra. Four students did use the term numeracy on one or more occasion, but all four appeared to use it interchangeably with the term *maths*. Dee, who reported a high level of mathematics anxiety, said that she “liked the maths in the numeracy exam” which suggests that she might not be so anxious about all aspects of mathematics and perhaps making it much clearer to students what specific skills they will need could go some way to reducing their anxiety.

It is not only what we call the skills needed for nurses that causes confusion. One student was clearly confused about the terminology related to multiplication, thinking that *timesing* and *multiplying* were different in that *timesing* related to small numbers as in tables whereas multiplication related to larger numbers. Weeks et al (2001) suggest that using words for which the student does not have an adequate conceptual model is effectively the same as using a foreign language and does not help the student in their

understanding. It appears that as educators we might be adding to the confusion by using a range of vocabulary that we are not clearly defining or using consistently. For example sometimes we use the term *multiplication tables*, and at others *times tables*. Likewise, we sometimes refer to *subtraction*, and at other times *taking away*. The simpler terminology is invariably intended to help the understanding of the students, especially if they are younger children, and it is good practice to do so, but do we just assume that students will see the relationship of these terms and make the links for themselves?

As previously argued, a commonly understood language is an essential component of education (Matheson and Matheson 2000), but language takes many forms including pictures and signing as well as words, and in mathematics, symbols are used extensively. In fact, according to Young et al (2013), symbols are a ubiquitous and defining feature of mathematics, and are important beyond the representation of numbers within the context of numeracy in that they are also used to represent units of measurement such as grams and milligrams. However, for many students these symbols add to the mystique and to the perception of mathematics as a highly technical and remote subject (Ernest 1991).

Weeks et al (2001) acknowledge that the teaching of medication dosage calculation skills usually relies on words to convey the problems that the students are required to solve. They add that the use of the written and spoken word is such a universal feature of human communication that assumptions about the process are rarely questioned. However, Weeks et al (2013b) argue that a theory-practice gap is created when students are

unable to see the meaning embedded in the language and symbols used within medication calculation activities. It is therefore important that the language used, whether words or symbols, is clearly understood by the learner as a lack of clarity could impact negatively on them causing misunderstanding, confusion and ultimately a reluctance to further engage with the learning experience. It was clear that some students saw mathematics as a mysterious world that they were either afraid to, or felt they had not been permitted to, enter. This reflects the absolutist philosophy of mathematics as outlined by Ernest (1991) which, as argued above, makes the subject appear remote and inaccessible for some students. Anderton and Wright (2012) agree that students' impressions of mathematics do often correspond with this absolutist philosophy due to the way in which they have been taught. Inevitably the use of specialist subject language, jargon or symbols will add to the mystique, as will not clarifying the links between the different terminology used in different settings, and it seems that for some students this discourages them from wanting to explore the subject further. Something as simple as a glossary of terms (including symbols) may be a helpful resource for some students.

The lack of distinction between the terms Mathematics, Numeracy and Arithmetic extends to the key contemporary authors in the field. Wright (2007, 2011) uses the terms maths, numeracy and arithmetic when discussing the skills that student nurses need to improve their medication calculating skills, but then argues that nurses in practice are not “doing maths” (Wright 2011). She acknowledges that nurses need numeracy skills to perform medication calculations but argues that they are performing a

nursing skill not a mathematics skill. Gatford and Phillips (2006) entitle their book *Nursing Calculations* but write about the *arithmetic* of nursing within the text, whereas Starkings and Krause (2013) also use the term *calculations* in the title of their book but talk about *numeracy skills* within the text. Bull (2009) uses the term *maths anxiety* when exploring this issue in student nurses and focusing on remedial work. I myself, when undertaking a literature search for this study started with a search of *numeracy anxiety* but quickly expanded this to *mathematics anxiety* and when choosing an assessment tool to determine the extent of anxiety in the cohort of students, settled for the 'Abbreviated *Maths Anxiety Scale*' (Hopko et al 2003). Perhaps more clarity and consistency of the terminology used would go some way to reducing confusion and therefore alleviating some of the anxiety experienced by students.

Students' Inherited Legacy of Mathematics

It was evident that each of the students who participated in the interviews had their own personal mathematics history consisting of previous memories and experiences both at school and in their life outside of school. The earliest memories they could recall ranged from age 4 to 9, and were, without exception, positive memories. The age at which they claim they started to experience anxiety ranged from 5 to 16 years old, which does not align with Arnold et al's (2002) theory that negative attitudes towards mathematics start very early, even before the age of 5 when they start Kindergarten (USA). However, it does fit with Scarpello's (2007) claim that in schools in the USA anxiety related to mathematics can begin as early as the 4th grade (9-10 years old) but peaks in Middle and High School. Likewise

Mackenzie (2002) undertook a study of 466 students of which 73% claimed to have enjoyed mathematics at primary school but this had dropped to 48% by secondary school. This suggests there is no one key stage of education where school mathematics teachers can focus specifically on trying to prevent mathematics anxiety from developing, so they need to be aware of the potential throughout the entire school curriculum.

In the survey stage of this study, one student drew a marked decline at age 22 on the graph representing her feelings about mathematics, and labelled this as *access course*, suggesting that she felt the access course contributed to her negative feelings about mathematics, so those who teach mathematics in further and higher education also need to be aware that there is still the potential for mathematics anxiety to develop even in adult learners.

Geist (2010) argues that it is when children enter formal schooling that problems with mathematics anxiety start to develop, due to the focus shifting from the construction of ideas to getting the right answer. Certainly some students talked about their anxiety being related to feelings about *not getting it right*. Ann recalled experiences of getting upset in tests as she felt she was getting the answer wrong and Barbara described how she was reduced to tears when she felt that she could not do something that all her peers appeared to be able to do. In two cases students identified anxiety related to punishment for getting the wrong answer. Five other students attributed the onset of their anxiety to a point at which they recognized they were not doing well in the subject, were falling behind their peers or could not understand what they were being taught.

Chinn (2008) argues that mathematics is inherently judgmental in nature in that there is almost always only one right answer, therefore the student is either right or wrong, there is no middle ground. This is aligned to the absolutist perspective that mathematics knowledge is certain and unchallengeable (Ernest 1991) and that there is a fixed body of knowledge (Anderton and Wright 2012). This judgmental nature can exacerbate the sense of risk associated with learning and discourage students from becoming involved. This certainly explains the reluctance of some of the students interviewed to engage more fully with the subject. Bandura (1997) explains that anxiety about their ability to cope within a particular context causes people to worry about what others may think of them and subsequently to avoid engaging with the situation. He goes on to argue that some people with acute anxiety will even avoid objectively safe situations (an example might be performing simple arithmetic) for fear that this might lead to something more threatening. Whilst it is true that there is only one correct answer when it comes to medication calculations, there is often more than one method of arriving at that answer. Even for basic arithmetic processes such as addition and multiplication, there is more than one mathematically sound method that can be used to arrive at the correct answer. For example, for multiplication some students will use a number line method;

$$\begin{array}{r} 254 \\ \times 36 \\ \hline \end{array}$$

whereas others will use a grid approach;

	200	50	4	
30				
6				

This can be problematic in a classroom setting, where the teacher may be trying to demonstrate a medication dosage calculation, but the students in the class are familiar with different methods of performing calculations. It may also create further anxiety for individuals if they feel uncomfortable about admitting that they have learnt a different method. It means that the teacher teaching or supporting the students has to be familiar with, or at least able to follow, a range of methods for performing a single calculation, and regularly acknowledge where there is more than one correct way. Different medication calculation books also adopt different methods as do different on-line resources, but this tends to be less problematic as students can be encouraged to choose the resources that they find easiest to follow. However the issue of different methods can be problematic in the clinical area, where students sometimes complain that they cannot follow the method their mentor is using and vice versa.

OFSTED (2009) identified that many schools – particularly secondary schools – are placing too much emphasis on routine exercises and on

teaching to the test. They acknowledge that while this style of teaching prepares pupils to pass examinations, and gain necessary qualifications, it is less effective in promoting the required understanding to apply mathematics to new situations, solve problems and communicate solutions. In other words it does little to produce students with good numeracy skills. However, there is increasing pressure on schools to improve examination results, and OFSTED itself will judge a school partly on its GCSE and A-Level results. It is very difficult for teachers who are under pressure to get students the best possible examination results to reduce the emphasis on teaching to the test. A major redesign of the curriculum and GCSE examinations would be required to enable teachers to focus on developing numeracy skills rather than passing mathematics examinations. This view is supported by Anderson et al (1996) who propose that what is needed in mathematics teaching is a greater balance between the generality of the subject and enough situational context for its application. However, Chinn (2008) argues that whatever changes are made to the mathematics curriculum in England, there will always be a problem with mathematics anxiety. Nonetheless, a change of focus in the curriculum could help to reduce the problem, and it may well be that there is a need to move away from the traditional absolutist approach to teaching mathematics towards a fallibilist approach which involves contextualizing mathematics using real world applications.

It was evident that parental or family attitudes to mathematics had also influenced the students who were interviewed. They were asked about their family's attitude to mathematics and in particular what their parents' involvement in their mathematics education had been. Some clearly saw

difficulty with mathematics as a family trait, in some cases identifying parents or siblings as also struggling with mathematics or experiencing mathematics anxiety. With regards to parental involvement in their mathematics education, students generally recalled encouragement from their parents rather than specific help with their mathematics. However, some felt that their parents were not unduly concerned about their progress in mathematics particularly if their parents were not good at mathematics themselves. This can be aligned to Bourdieu's theory of capital (Bourdieu 1986). Mathematics skills could be seen as a form of cultural capital and if parents do not possess good mathematics skills (cultural capital in the embodied state) or do not recognise the importance of mathematical skills, they may be less likely to be concerned about their children also lacking these skills. In other words they may not perceive these skills as a valued resource.

Chinn (2008) argues that, in contrast to core skills such as reading and writing, it appears socially acceptable to admit to having low ability with numbers, so children may be less concerned, and even reassured, about their own failings in the subject if they recognise that their parents are in the same situation. Datta and Scarfpin (1983) identified the term *Socio-cultural mathematics anxiety* as one type of mathematics anxiety which arises as a result of commonly encountered cultural beliefs about mathematics such as *only very clever people can do maths*. They go on to argue that sociocultural mathematics anxiety can not only lead to maths phobia, but also sanctions people to admit in social situations that they are unable to do mathematics. Of course this will depend on the specific social situation that the individual is

in. Whilst they may feel comfortable admitting their perceived lack of ability to family and friends, they may not feel able to do this in an academic setting.

So, a student nurse finding themselves at university on a programme of study which requires numerical skills may feel *out of place* and many admit to feeling as if they are there *under false pretences*. Matheson (2006) identified this feeling as being common amongst some students, particularly those in the lower socio-economic groups, and that this feeling may persist beyond graduation. However, it is clear that some of the parents of the students interviewed did see mathematics qualifications as being important enough to invest in additional private tuition, although in all three cases this was directly related to passing mathematics examinations. Bourdieu (1986) claims that the domestic transition of cultural capital is possible, for example through investment in education, so this investment could suggest that these parents did feel that the acquisition of a mathematics qualification (cultural capital in the institutionalised state) was of value and would advantage their child in the future. Other students reported a lack of any real communication with their parents about their mathematics, suggesting that some parents were not concerned enough about their child's progress in mathematics to be discussing it with them on a regular basis, perhaps not feeling that it was a priority or not valuing mathematics skills and qualifications as an asset. This is more likely to be the case if they do not possess these skills or qualifications themselves. Of course it could be the case that they trusted the school to be ensuring that adequate progress was being made, or felt that they had received sufficient feedback about their child's progress from parents' evenings or school reports.

One student reported a perceived lack of parental support in that she had wanted her mother to intervene in her school's decision about the mathematics qualification she would be entered for. This student had subsequently passed a CSE qualification at Grade 1 which is considered equivalent to a GCSE pass grade. However, she still reported high levels of mathematics anxiety and still felt that, had she been allowed to go into the stream that she wanted, her current ability and confidence in mathematics would be substantially better.

Regardless of the reasons the effect was that many students did not inherit a sense of importance related to mathematics skills or qualifications from their parents. It could be argued that these families lacked the cultural capital required to engage in discussions or negotiations about their child's mathematics education, or to foster a mathematics culture within the family. Di Maggio (1982) argues that teachers communicate more easily with students who participate in elite status culture, give them more attention and special assistance, and perceive them as more talented or gifted than students who lack cultural capital. If this is true then it can be argued that students or families who do not participate in elite status culture are less likely to get the attention or assistance that they need to succeed in the subject.

None of the students interviewed appeared to have received sufficient attention and support with their mathematics at school. In other words there might have been a mismatch between the expectations of the teacher and the needs of the student. Matheson and Matheson (2000) argue that when the cultural capital of one group does not coincide with that of another a

space appears and this space can be termed *cultural distance*. The cultural distance that exists between a student and their teacher will inevitably impact on their relationship and the learning that takes place.

Matheson (2006) explains that many students from lower socio-economic groups do not consider themselves to be the type of person to be a university student. Socio-economic groups were not determined for the students in this study nor were they asked about their feelings about being a university student, but some students did talk about a feeling of being at university under false pretences:

I'm sure someone made a mistake in accepting me on to this programme (Ina)

Experience suggests that it is certainly the case that some student nurses do not feel like *real* university students. This is partly due to the nature of the programme, with 50% of the time being in the practice environment and therefore off-campus, but may also be to do with the fact that nurse education was not always university based, so students may have family members who are nurses, but who did not go to university. Likewise they may work with qualified practitioners who have not been university students. Matheson (2006) goes on to explain that cultural distance is about *whether something is for the likes of me*, and in relation to mathematics it was apparent that some students did not see mathematics as *being for them*. For example, Dee described her perception of mathematics as being an unknown world that she did not want to venture into, which patently indicates that she did not see that world as being for her. Feelings such as these can

make students feel like outsiders which Matheson (2006) associates with the concept of *optimal cultural distance*, which is the point at which education becomes for oneself rather than not for oneself. Matheson (2006) goes on to argue that some learners, particularly those from lower socio-economic groups, experience a mismatch between their social identity and their academic identity and sometimes the two are incompatible.

There were other aspects of the student / teacher relationship which influenced the students' relationship with mathematics. However, only two of the students interviewed reported specific negative experiences with a particular teacher which contradicts the widely held anecdotal view that mathematics anxiety *often* results from a bad experience of an aggressive or domineering mathematics teacher. This was not what I was expecting. In the past many students had told stories of distressing incidents related to mathematics and I was anticipating that I would hear more such stories from the students interviewed, but this was not the case. Likewise in the survey stage of the study students were asked to record on a graph their feelings about mathematics across their lifespan. Only 7 (1.7%) drew a graph that indicated a severe decline in their feelings at one specific point in time. Again this does not support the commonly held belief that *one off* bad experiences are frequently the cause of mathematics anxiety.

Of the 7 individuals who did show a severe decline, the age at which this occurred varied considerably. For one student it was at age 5 which fits with Geist's (2010) argument that it is when children enter formal schooling that problems start to develop. She explains that children start to construct their ideas about mathematics from the first few months of life, but that on

entering school the focus shifts from the construction of ideas to “teacher imposed methods of getting the right answer” (Geist 2010: p25), or the move from a constructivist way of learning to a behaviourist way of teaching. This includes a focus on repetition and speed (timed tests) which Geist argues undermines the child’s natural thinking process. Two other students indicated that it was at age 10 that there was a severe decline in their feelings about mathematics. The remaining four were aged 13, 18, 22 and 38. As previously argued, the student who drew a marked decline at age 22 labelled this as access course, suggesting that they felt the access course contributed to their negative feelings and anxieties about mathematics.

What most students did report were experiences of teachers who could not cope or were just not interested in them. Fiona specifically mentioned that her teachers were not horrible, but she did perceive them as stressed and not interested in her. Other students reported a series of temporary teachers or reported teachers who could not cope with the class. The students were asked about what help was available to them at school, but none of them could recall being given any additional mathematics support. Badly run schools and a lack of resources were also mentioned as factors which students felt had affected their learning. So, whilst particular teachers were not unpleasant this could still be considered bad teaching for the affected students and the possibility that this could be one of the root causes of their mathematics anxiety fits with Du Sautoy’s (2011) argument that mathematics anxiety is often due to bad teaching in the past.

Scarpello (2007) also suggests that mathematics anxiety might be caused by past classroom experiences and the students interviewed certainly associate

such experiences with their own anxiety, although perhaps not in quite such a negative way as might have been expected. Noddings (2003) argues that teaching is relational and students learn best from teachers with whom they work closely and it matters to students whether or not they like or are liked by their teachers. The perception of some of the students that were interviewed was that how they fitted in was important. They recalled that those students who did fit in, or those who were naturally bright, made good progress but those who did not were more often left to their own devices. Obviously students are not able to work closely with mathematics teachers who are not there on a regular basis or who are stressed or disinterested. Therefore they are unable to build a positive working relationship with them, which has a negative effect on their learning.

It appears that for all the students interviewed the problems related to their early experiences of mathematics were multi-faceted. For each student there was a varying combination of issues related to a sense of becoming lost in the subject, a fear of failing, a perceived lack of parental concern about their progress in the subject and a lack of a supportive teacher-student relationship.

Anxieties Related to Mathematics.

Symptoms of Anxiety - All of the students interviewed described one or more symptoms that fit with the symptoms normally associated with anxiety, as did many of the students in the survey stage when asked for a word phrase or sentence to describe their feelings about mathematics. These ranged from mild to severe, as described by Ashcraft and Moore (2009) who said that symptoms could range from seemingly minor frustration to

overwhelming emotional and physiological disruption. According to Tobias and Weissbrod (1980) these symptoms include panic, a feeling of helplessness, paralysis and mental disorganisation. Physical symptoms include sweating and rapid heart rate, palpitations and / or nausea. Within the survey stage of the study, some students who reported high or very high levels of anxiety describe symptoms such as sweating, fast pulse and heart rate and feeling *sick to the stomach*.

The students who were interviewed also described symptoms that included an inability to stop crying, an inability to sleep, nausea, vomiting, sweaty palms, sweating generally, heartburn, tightening of the chest, a rapid heartbeat and palpitations, feeling hot, going red and frequently needing the toilet. These symptoms would suggest that students are genuinely experiencing some degree of anxiety related to mathematics as opposed to just *disliking* the subject.

Within the survey stage of the study students reporting high and very high levels of mathematics anxiety also used words like stressed, anxious and worried as well as scared, terrified and panic to describe their feelings about mathematics. These students also describe feeling stupid, silly or thick. Others claimed to feel depressed, afraid of punishment and a failure. Some of the students interviewed also reported the feelings of dread and overwhelming panic described by Tobias and Weissbrod (1980). Another described a desire to run away, and four of the students interviewed talked about their tendency to avoid mathematics as much as possible. Richardson and Woolfolk (1980) explain that avoidance behaviour is associated with what they describe as *worrisome thoughts*. Hopko et al (1998) suggest that

the poorer calculation abilities of individuals with high mathematics anxiety are not so much a consequence of these worrisome thoughts but are more likely due to an inability to withdraw their attention from these thoughts.

All the students reported that these symptoms were most acutely associated with mathematics examinations or assessments, although seven reported that they may have milder versions of their symptoms in mathematics lessons, tutorials or even when trying to learn or revise mathematics on their own. This reflects Allen's (2004) claim that there is evidence that the mere thought of mathematics can induce a state of panic in some students. It appears that this is not unusual as Tobias and Weissbrod (1980) explain that whilst people tend to experience mathematics anxiety in formal settings such as in a classroom or examination situation, it can also occur in more everyday settings.

Some of the students interviewed indicated that they had not expected to have to *do maths* as part of their nursing programme. Hembree (1990) noted that "otherwise capable" students were avoiding the study of mathematics and making subsequent career choices accordingly. Mackenzie (2002) noted avoidance levels of 33% amongst applied social science students, who in many cases may need to do mathematics as part of their programme of study, and within their subsequent practice, but they may not have realised this when applying. Although a GCSE in mathematics, or equivalent, is an entry requirement for this nursing programme, it seems that some students have assumed that it is just a *standard* entry requirement and have not associated it with an expectation that they will need to use mathematics within their study or within their field of work. It may be helpful to some

students if the exact requirements related to mathematics are made much clearer in the pre-course information that they receive, although great care would need to be taken regarding the information provided if it is to lessen the students' anxiety rather than discourage them from applying.

Mathematics Anxiety and Mathematics Ability - Ashcraft and Moore (2009) stress that mathematics anxiety is a significant impediment to mathematics achievement, and yet all of the students interviewed had achieved at least a GCSE Grade C or equivalent in mathematics, despite reporting high or very high levels of mathematics anxiety. When asked what they thought of their mathematics ability some of them clearly recognised that they were actually quite good at mathematics and yet still felt highly anxious about it. They recognised the dichotomy, but felt unable to align their level of confidence with their ability.

Bandura (1997) explains that effective personal functioning is not just about knowing what to do and being motivated to do it, but that it also requires self-belief. In other words it is not just about having the necessary skills but also about having confidence in your ability to use those skills. For these students, it seems they have the skills but not the necessary confidence in them. Bandura (1997) also points out that different people with similar skills or even the same person under different circumstances can perform quite differently depending on their self-belief at the time.

Other students did consider they had poor mathematics ability, despite evidence of previous successes in the subject. This fits with Tobias and Weissbrod's (1980) claim that mathematics anxiety directly influences a

student's confidence. However, a lack of confidence is itself considered to be a factor in further exacerbating mathematics anxiety (Dodd 1999). It could be argued that this creates a spiral effect with a lack of confidence causing further anxiety and that anxiety further reducing confidence, yet despite this, these students have achieved clearly identified mathematical successes.

Race (2010) claims that confidence is the single most important factor in success and one would normally expect success in a subject to increase a person's confidence. For example, Parsons et al (2011 p53) claimed that for the engineering students that she studied, doing well in their first year mathematics modules "naturally increased their self-confidence". However this does not appear to be the case for the student nurses who were interviewed as part of this study. This is important as when providing mathematics support we tend to focus on supporting the development of the students' mathematical skills. Whilst this may have a positive impact on their demonstrated ability, and improved assessment results suggest that it does, it may not be increasing their confidence in their ability or reducing their anxiety as we would expect.

One could question whether it matters if students, or qualified nurses, lack confidence or experience mathematics anxiety as long as they are able to demonstrate safe skills in practice. However, the NMC (2012) require nurses to be numerate, and Coben (2000) explains that to be numerate means to be confident and comfortable with one's judgements as well as being competent. A student who experiences mathematics anxiety will not be comfortable with their judgement and it could be argued that this combined with their lack of confidence means that they do not meet the NMC numeracy

requirements for registration as a qualified nurse, even though they can pass the required assessments.

Ashcraft and Kirk (2001) found that students with higher levels of mathematics anxiety displayed lower working memory spans for numerical tasks, along with longer reaction times and higher error rates. Both longer reaction times and higher error rates are potentially problematic in the clinical environment. In addition, a practitioner who lacks confidence in their skills may be reluctant to demonstrate their calculations to another person, as is required as part of a double-checking process, and is also unlikely to be enthusiastic about teaching these skills to more junior practitioners.

Mathematics anxiety will also add more stress to a role that is already potentially stressful, with some students expressing concern about being safe in practice. Some students seemed genuinely concerned that they may cause harm or even death to a patient entirely as a result of their mathematics ability. This reflects the concerns of Gladstone (1995) who argues that, within the healthcare professions, a lack of mathematics ability can lead to medication calculation errors in practice. However, Wright (2010) argues that following a review of the literature on medication errors she found insufficient evidence to suggest that medication errors are caused by nurses' poor calculation skills. Nonetheless a report from the National Patient Safety Agency (NPSA 2009) reported that there has been a significant year-on-year increase in reported medication incidents, and in 2007 they received 100 incident reports of death and severe harm as a result of medication errors. *Wrong dose* was amongst the most frequently reported error and it is

therefore reasonable to conclude that errors in the calculation of medication dosages have been made. If nurses are required to calculate medication doses for their patients, then sound calculation skills, and well-placed confidence in those skills must increase the chances of accurate doses being administered and will therefore contribute to improved patient safety.

Within the survey stage of the study a comparison of anxiety levels based on the students' highest level mathematics qualification found no statistical difference in the levels of anxiety between those students whose highest mathematics qualification was a GCSE and those with higher level qualifications. Hewitt (2001) identified that even high achievers can experience mathematics as something to be memorized rather than understood, and this may help to explain why some students with A' Level qualifications in mathematics still report high levels of mathematics anxiety.

There is also an anomaly in that whilst achievement rates in mathematics at GCSE are higher in girls (OFSTED 2007, 2009), mathematics anxiety rates are also higher in girls (Geist 2010, Sabin 2001). This supports the argument that levels of ability and confidence are not necessarily aligned when it comes to mathematics.

The findings of this study suggest that improving students' mathematical skills does not automatically increase their confidence or reduce their level of anxiety and yet the support that is offered to students is normally focused on improving their mathematical skills, despite the fact we know that students must have previously learnt these skills in order to access the programme. In addition it is often the case that some students need further support with the

same level of numeracy skills as they progress through their programme of study. In other words, it is sometimes necessary to re-teach the skills that were taught in the first year to second and third year students, despite the fact they have successfully passed previous assessments of these skills.

Race (2010) explains that learners often feel frustrated and disappointed when they have mastered something at one point in time, only to discover that they cannot recall that learning at a later stage, and this frustration and disappointment is likely to increase their anxiety. However, there is some evidence to support the theory that reducing mathematics anxiety positively influences mathematics performance. A meta-analysis by Hembree (1990) showed that successful treatment of mathematics anxiety in adults led to a significant improvement in their calculation performance, even though their treatment did not involve any mathematics training. A later study by Kamann and Wong (1994) showed that reducing mathematics anxiety also positively influenced mathematics performance in children with mathematical learning difficulties. Therefore we need to reconsider our approach to this problem, and develop strategies that address the mathematics anxiety and lack of confidence as well as focusing on the development of numeracy skills.

Race (2010) claims that many staff in higher education waste much of their time and energy trying to do things that do not work and never will work. He argues that our job is to make learning happen and in order to do this we need to stop wasting time and energy doing things that do not work, and focus our energy on helping students to become excellent learners. Weeks et al (2013b) also argue that the traditional way in which numeracy has been taught creates not only a theory – practice gap, but a knowledge –

performance gap that separates knowing that from knowing how. This means that those supporting students with the development of numeracy skills need to consider a shift away from the remedial style teaching of mathematics towards an approach that tackles the anxiety and supports students to engage with self-directed and lifelong learning strategies. In other words, this may mean a shift away from an absolutist / behaviourist approach to a fallibilist / constructivist approach to learning.

Aspects of Mathematics Which Cause Anxiety – Within the survey stage of the study some students were able to differentiate particular aspects of mathematics that caused them anxiety. They included comments such as *It depends what aspect? Fractions, percentages and decimals are worst, some parts of maths I'm really good but struggle somewhat on other parts and I feel I am ok with some maths but others make me panic i.e. long division.*

When asked about what aspects of mathematics caused them anxiety, all the students that were interviewed referred in some way to a sense of being faced with something they could not do, or thought they would not be able to do. Again in some cases this related to a specific aspect of mathematics such as fractions or percentages. For other students it was a more general fear of mathematics. So it seems that the factors which trigger mathematics anxiety are different for each individual, which makes it a difficult problem to tackle for those trying to provide support.

Memory – Memory was another factor identified by some students related to their mathematics anxiety. In the survey stage of the study, many students alluded to issues with memory, that they have a complete block when it

comes to mathematics or that they can never retain the information. Other students stated that they felt apprehensive because they may have forgotten how to complete some mathematical problems or that they were *nervous* because they found it difficult to grasp formulas – and then forgot them easily. One student reporting a high level of mathematics anxiety stated *normal maths i.e. dividing, adding subtracting I'm ok with, however anything that needs memory i.e. formulas I struggle with*. Another of the interviewed students also commented on her memory being a factor of her anxiety, arguing that if she did not practise mathematics regularly she quickly forgot how to perform the calculations she had learnt.

Remembering formulas also appeared to be problematic for two of the students that were interviewed. Race (2010) argues that students should not be concerned about forgetting what they have learnt, as it is a normal phenomenon to forget what is learnt the first time around. He suggests that if a particular concept takes an hour to grasp the first time but then *slips away*, it may only take 10 minutes to regain at a later stage. If it slips away again it may only take 5 minutes and so on. He concludes that it is not how long you spend learning something that counts, but how often you learn it. However, Race does not explain at what point he believes the learning becomes sufficiently embedded for the student to know it without having to relearn it. In the practice environment student nurses need to be able to perform medication calculations without having to relearn the method first. Of course there is no reason why they cannot use prompts such written down formulas or aide-memoires.

Whilst students are suggesting that their memory, or perceived lack of memory, is affecting their anxiety, Hopko et al (1998) suggest that the students' anxiety is likely to be affecting their memory. They explain that the worrisome thoughts, identified by Richardson and Woolfolk (1980) are hard to inhibit and will absorb the students' working memory and attentional resources. Therefore if, as argued above, we could find some way of reducing the students' anxiety, they might notice an improvement in their memory related to mathematics.

Examinations – One factor that clearly created particular anxieties for many students was mathematics examinations. Some students in the survey stage commented that they were confident until faced with a test or that having to take a mathematics examination made them very nervous. Others commented that they were only scared when an examination was involved or that they were quite positive when alone but became very anxious when being watched or graded.

All of the students that were interviewed reported increased anxiety related to examinations or assessments. Two of the students reported that they would get equally anxious for other examinations, but seven reported that their symptoms were more severe in relation to mathematics than they would be for any other type of examination or assessment. The Higher Education Academy (2012) states that assessment of student learning is a fundamental function of higher education. Assessments of the students' numerical competence are necessary and the NMC (2010) advocates that these must be assessed in the theoretical (university) component of the programmes as

well as in the practice environment. However, it could be argued that these do not need to be in the form of a timed, paper-based examination.

Hutton (1998a) claimed that student nurses were particularly poor at solving paper-based written problems and therefore nursing mathematics should be taught and tested in realistic situations. This view was shared by some of the students in this study, who felt they learnt much better from hands on experience and would much rather learn by *doing it in practice*. There is evidence to suggest that on-line assessments and Objective Structured Clinical Examinations (OSCEs) are a more realistic and effective way of assessing students' competence, particularly related to medication management. Hutton et al (2010) argued that making numbers real and encouraging practice in authentic situations removes much of the fear that students associate with mathematics. However, with cohorts of 500+ students, individual OSCEs would be a huge undertaking, so on-line assessments, particularly those that reflect real-life scenarios may be a better approach.

A study by Hutton et al (2010) showed that comparable results were achieved by students undertaking an on-line simulated assessment as by students undertaking a comparable OSCE. However, whilst on-line or computer-based resources suit many students very well, experience suggests that some students, particularly those with high levels of numeracy anxiety still need a lot of support to engage with these resources and to be able to use them effectively and independently.

Mathematics in the Practice Environment.

As part of the generic standard of competence the NMC (2010) requires that all registered nurses must be able to work autonomously and that they must practise with confidence. In order for students to achieve this level of confidence, 50% of the entire pre-registration nursing programme is delivered on placement in the practice setting. By the time the interviews were conducted all of the students had been out on their first clinical placement in practice. Generally they reported a higher level of comfort with the mathematics that had been required of them during this first placement. Four students commented specifically on their lower levels of anxiety being related to their understanding that they would work with other people and therefore would not be undertaking calculations on their own. Clearly this is perfectly acceptable for a first placement, but it is important to note that by the time they enter the register as qualified nurses they need to be able to work autonomously and therefore be competent and confident to complete medication calculations on their own.

In the survey stage of this study 61.8% of students reported moderate, high or very high levels of mathematics anxiety, and Arnold (1998) argues that this level of anxiety prohibits nurses from using their mathematics skills appropriately. There have been several studies which identify that many student nurses do have difficulties with accurately calculating medication doses in practice (Hutton 1998a, O'Shea 1999, Wilson 2003, Wright 2007) and as Gladstone (1995) points out, this can lead to medication calculation errors.

Mentors in practice appeared to have a key role in reducing the students' anxiety levels in relation to medication calculations, and students said that they liked being given opportunities to practise their calculation skills under the supervision of their mentor in a safe environment. However, this support is based on the assumption that the mentor is both competent and confident in their own practice. A study by Warburton and Khan (2007) has shown that many registered practitioners still have inadequate calculation skills and Bayne and Bindler's (1988) study suggested that the years of experience and educational background of registered nurses appeared to make no difference to the incidence of medication errors made by them, suggesting that competence in calculation skills does not increase with experience. However it would appear that confidence does, as Perlestein et al (1979) found that experienced nurses were more certain in their judgement, i.e. were confident that they were right, even when they were wrong. Although this study is now somewhat dated there is no evidence to suggest that the situation has changed. Therefore it could potentially be the case that the student is depending on a mentor whose own skills are deficient. It could be argued that it is better to be competent but not confident rather than confident but not competent. However the NMC specifically states that it requires practitioners to be both. (NMC 2010).

The opportunity to practise medication calculations on a regular or even frequent basis appeared to be an important factor for some students, with some claiming that they needed to practice calculations everyday if they were to retain what they had learnt. Some felt that even a break of a few days meant that they would not be able to recall what they had previously

learnt. Many of the students reported that they found the practice areas less stressful than the university environment which was interesting as the clinical environment is often considered to be a stressful one, either because practitioners are extremely busy, or in some cases due to potential or actual emergency situations. When such situations arise, nurses need to function quickly and effectively, sometimes against a somewhat chaotic background of shouted instructions, urgent demands and even a sense of panic. Stress is one of the factors that is often identified as being problematic for individuals with mathematics anxiety.

Ashcraft and Moore (2009) argue that individuals with mathematics anxiety tend not to perform well in stressful situations, due to what they describe as an “affective drop”. This is a decline in performance which occurs when mathematical calculations are attempted under timed, high stakes conditions. It would not be appropriate for a nurse in such a situation to be relying on somebody else to check their calculations, so the ability to function autonomously really is essential. Obviously student nurses on a first placement would not be expected to perform at the level that would be expected of a qualified nurse, but it is important for educators to ensure that students do recognise that they will ultimately need to perform calculations autonomously, and that by the time they do enter the register as qualified nurses they need to be both competent and confident under pressure.

As part of the standards for pre-registration nursing education the NMC (2010) identified five *Essential Skills Clusters* (ESCs), one of which is Medicines Management. ESCs are sets of skills that it is considered essential for a qualified nurse to possess. Whilst these are generally skills

that must be achieved by the point of registration, the NMC does determine specific levels of skill that must be achieved by each progression point of the undergraduate programme. In relation to medicines management, by the first progression point (the end of the first year) students must demonstrate “competence in basic medicine calculations relating to tablets and capsules, liquid medicines and injections” (NMC 2010 p134). The students that took part in this study have two placements during the first year in which to achieve this level of competence, but on completion of the first placement it was clear that for some of the students who were interviewed there was still a gap between their current level of competence, and that which they need to achieve by the end of the first year. For educators it is difficult to find a way of ensuring that students are aware of the requirements without further increasing their anxiety levels.

What Students Found Helpful

As shown in the results some students felt that there was not anything that could be done to help them overcome their anxieties related to mathematics or to improve their confidence in their mathematical skills. However, when encouraged to think about what they had found helpful in the past, all the students focussed immediately on assessments.

Five of the students that were interviewed identified practise papers as one of the things that they had found helpful in preparing for their assessments. They particularly identified regular and repeated completion of practise papers, although they did all appear to take a very strategic approach to this, with some advocating a very short-term utilisation of this preparation method. Skemp (1976) argues that many learners adopt instrumental approaches

such as this in the belief that success in mathematics requires the memorising of formulas, reinforcing the absolutist philosophy of mathematics. Hewitt (2001) claims that even high achievers can view mathematics as something to be memorised rather than understood. One student specifically stated that there was no point in starting revision too early and that she would wait until two weeks before the examination and then revise intensively every day. Biggs and Tang (2007) describe such a strategic approach to studying as an achieving approach which is about putting effort into organised studying with the intention of fulfilling assessment requirements.

he problem with this approach was that whilst it does help students to pass the assessment, they do not necessarily retain what they have learnt, so it is not an effective long term learning strategy. The student who adopted this approach admitted that she anticipated that she would be unable to recall what she had learnt a few weeks later. Students appeared to be focussing on passing the assessment rather than learning the mathematics skills that they would need in the practice environment. Weeks et al (2013b) describe this as a knowledge-performance gap and it reflects what appears to be happening in schools which come under much criticism for teaching to the test rather than teaching to develop the students understanding.

Geist (2010) argues that even when children start their formal schooling the focus of their education shifts from the ideas that children were constructing prior to the commencement of formal schooling to “teacher imposed methods of getting the right answer” (Geist 2010: p25). Geist goes on to explain that this includes a focus on repetition and speed (timed tests) which she argues

undermines the child's natural thinking process. This focus continues through school with OFSTED (2009) identifying that many schools - particularly secondary schools - are not teaching mathematics well enough because they place too much emphasis on routine exercises and on *teaching to the test*. However, as previously argued, OFSTED itself is partly responsible for creating this culture in schools as they will judge a school on its GCSE and A-Level results, so creating a pressure on teachers to get students the best possible examination results, inevitably leading to more emphasis on teaching to the test.

Of course, it can be argued that repetition is a good way to learn some aspects of mathematics such as multiplication tables and being able to offer the answer quickly and accurately may serve to increase a person's confidence in their mathematics ability. However, one student appeared to have misunderstood the purpose of practise papers and taken the principle of rote learning to an extreme by trying to rote learn the answers to the questions on the practise papers in the hope that the same question might appear in the actual examination. This response suggested that this student was focussed solely on passing the examination, and not on learning the methods that she could subsequently apply in practice.

Grove (2012), like many academics, believes that it is the current mathematics provision at school that leads to students learning by rote rather than through their own independent techniques. One problem with a strategy that focuses on passing the assessment is that it leads to surface learning rather than deep learning. Beattie et al (1997) argue that it is unrealistic to assume that a deep learning approach is always desirable and that

sometimes it is necessary, dependant on the nature of the knowledge, to adopt a surface approach. However, Webb (1997) argues that a person using a surface approach does not see past the immediate subject matter to the sense and meaning of it and they would simply try to remember or rote learn the material, as suggested above. In the context of Bloom's taxonomy of learning (Bloom et al 1956, revised by Anderson and Krathwohl 2001) it could be argued that the student is not moving beyond the first level of thinking skill, namely remembering, to the higher levels of understanding and application.

Donnison and Penn-Edwards (2012) claim that some surface approaches to learning such as memorisation do have a place in certain areas of study such as mathematics, although a surface approach was found to correlate with lower grade averages (Burton et al 2009). So it seems that whilst a surface approach may be a suitable starting point, students need to be able to move on to deeper approaches whereby they can develop an understanding of mathematical principles that they can apply in a variety of circumstances. Anderton and Wright (2012) argue that an active deeper approach to learning mathematics is more likely to be achieved through a constructivist approach to teaching which emphasises self-discovery, focuses on real world examples and problems and encourages discussion (Threlfall 1995).

As all the students in this study were first years, it was not yet possible to determine whether deeper approaches to learning developed as they progressed through the programme. So, adopting a surface approach could mean that students lack the underpinning understanding that would give

them confidence in their knowledge and ability. This might help to explain why some students are still so anxious about their ability despite being successful in previous assessments and examinations. It may also help to explain the anomaly between the higher achievement rates of girls at GCSE (OFSTED 2007, 2009) and higher mathematics anxiety rates amongst girls (Geist 2010, Sabin 2001)

In higher education we continue to focus on the assessment of the students' mathematics ability, particularly on pre-registration nursing programmes, where such assessments are required by the NMC (2010). Donnison and Penn-Edwards (2012) argue that the use of assessment as a motivator for surface learning is a valid pedagogy and forms an initial learning stage in the student's progress towards being lifelong learners. For as long as we are required to assess numeracy by examination, the provision of practice papers is necessary especially as there is little time allocated in the students' timetable for the teaching of mathematics or numeracy skills. However it is recognized that they can further exacerbate anxiety for some students.

The reason for relatively little teaching of mathematics or numeracy in pre-registration nursing programmes is that it is assumed that the students already have the mathematics skills required and this is the reason for requiring a GCSE mathematics qualification or equivalent on entry and why potential students are assessed on their numeracy skills at interview. Of course, many students do have the skills required, appropriate confidence in those skills and minimal anxiety related to mathematics. For them a practice paper is an ideal way of ensuring they know what will be expected of them. However, assessment results show that many others do not have the skills

required, or at least are not able to demonstrate them in an assessment situation and, as the results of this study have shown, 68.1% of the students in the cohort studied reported moderate, high or very high anxiety related to mathematics.

As educators who are trying to support students in developing their mathematical skills and confidence, it seems that we need to try and shift the focus away from the assessments towards developing skills that transfer into clinical practice, in an attempt to encourage deeper, more embedded learning. This would require a strategy that places greater emphasis on self-discovery and real world problems as advocated by Weeks et al (2001). There have been many strategies developed to encourage the deeper learning of mathematics related to clinical practice and these include some very valuable interactive on-line resources that reflect real life clinical situations. For example Weeks et al (2001) developed a realistic computer program which was able to test large numbers of students in a safe environment using simulated scenarios. This resource has subsequently been shown to achieve 100% pass mark in assessment for all 210 students that took part (Macdonald et al 2013) However, some students took several attempts to achieve this 100% pass mark but, as previously stated, Hutton et al (2010) have shown this on-line resource to have a reasonable correlation to the results achieved by students undertaking a comparable assessment as an OSCE.

The university uses a virtual learning environment called Moodle and the department has created a substantial amount of numeracy support material that is available to students although this is not an interactive resource per

se. Six of the students who were interviewed commented on this when asked what they found helpful but they were split in their opinions related to it. Four reported that they found it helpful but two claimed that they were unable to engage with computer based resources, one because he had difficulty reading from a computer screen. This problem might well be solvable by changing the backgrounds, colours and fonts but the student may need support in learning how to make these changes.

The other student did not like the computer-based resources because she felt that it assumed a baseline level of mathematics skill, which she felt she did not possess. This may well be a confidence issue rather than an ability issue and again might be resolved by supporting the student to the point where she is able to engage with the resource independently. This reflects the experience of staff in the department that some students, despite having appropriate entry qualifications, need support starting with basic arithmetic. Based on my previous argument that all students on the programme have previously been successful in passing mathematics assessments, this need for support is likely to be as a result of their anxiety rather than their ability. Therefore whilst on-line resources are invaluable, some students need supporting to a point where they are able to engage with them.

Some students found other learning resources such as medication calculation texts and other on-line resources useful to a limited extent, but again this seemed to be dependent on their initial level of confidence. Those with high levels of anxiety and low levels of confidence appeared more reluctant to engage with any of the available resources other than face to face support, and ideally (for them) one to one tutorial support. However it

should be noted that the students studied were still in the early stages of their programme and it is anticipated that they might start to find the wider range of resources more valuable as they progress through the programme.

Race (2010) argues that nowadays 'lecturing' in the traditional sense is obsolete, and that in the current age of online resources the role of staff in Higher Education is no longer about giving students content but is much more about supporting their learning. Weeks et al (2013b) also argue that traditional classroom based methods of teaching medication dosage calculations are divorced from the real world of practice and are a *weak and impoverished* method of supporting the students' learning of these skills. Of course Weeks et al are focussing specifically on medication dose calculation, rather than supporting the acquisition of the underpinning numeracy skills. As such their focus is on the students' acquisition of medication management skills and competence, rather than on the reduction of mathematics anxiety, but it is clear that the two are inextricably linked.

So, perhaps as educators we need to focus less on a remedial model of re-teaching basic numeracy skills and more on supporting students to engage with the wider range of interactive resources that will help them to achieve deeper learning which relates to the practice environment and which they retain. This should also enable them to take control of their own learning, so positioning them to engage in life-long learning. Ideally this would require more small-group and one-to one teaching, but potentially over a shorter time frame.

Small group and one-to-one teaching is already available to students in the faculty, outside of their normal timetable, although students do tend to access it as and when they have an assessment pending. Seven students said that they found this support helpful, with one student claiming this was the only way in which she could learn. The reasons that students gave for their preference were that they could work at their own pace, use their own preferred methods, and ask questions without being embarrassed. They also identified that one-to-one tutorials enabled them to identify exactly where they were going wrong.

The students that had previously accessed private tuition had also found this helpful due to the one-to-one approach. The student whose mother had paid for private tuition particularly liked that her tutor appeared sensitive to her mood and emotions, and knew when to stop the session because the student had had enough. This suggests that for this student, it was not just a case of being able to ask questions and going at her own pace, but it was also important that the tutor was sensitive to her feelings and reactions. This is an example of *teaching with emotional intelligence*.

According to Mortiboys (2012), an emotionally intelligent teacher does not just know their subject and teaching methods but has the confidence to be flexible and responsive to their student. This tutor appeared to have had this ability and it was clearly valued. Mortiboys (2012) goes on to say that a learner's emotions have an effect on their learning and the teacher has a significant role in shaping those emotions, so it is important for the teacher to recognise and work with their own feelings and those of their student. This is much easier to achieve in a small group or one-to one situation where the

individual can be acknowledged and a look of confusion or concern quickly spotted. Students are also far more likely to become motivated and engaged in their learning experience, when they feel acknowledged, valued and respected, and are more likely to become confident in their abilities (Mortiboys 2012). An anxious student is more likely to feel acknowledged, valued and respected in a one-to one or small group setting than they are in a large classroom. However, it needs to be recognised that with cohorts of 500+ students it is not possible to offer one-to-one tutorials to everyone, so resources need to be rationalised to ensure they provide maximum benefit to those who need them the most.

Calculators - Four students reported that being allowed to use calculators would help to reduce their anxiety particularly if they were allowed to use them within an examination. One student reported that she had used a calculator in the practice environment and found it to be helpful in checking her answers when doing calculations in the clinical area. She did seem to be under the impression that nurses should not use calculators in practice, although this is not the case as calculators are legitimately used in many clinical settings. The NMC (2010) do acknowledge and accept the use of calculators, but stipulate that they should not be used as a substitute for sound numerical competence. However, one student suggested that she would rely on a calculator rather than her own skills in practice. The problem with this is that people do make calculation errors with calculators, and so blindly accepting the answer on a calculator is potentially dangerous. If a student is to use a calculator, they must be sure that they know how to use it accurately, and be confident that the answer they have calculated is correct.

There are a number of ways in which they can do this, for example estimating the answer before performing the calculation (e.g. I need 30mg, I have 50mg in 2mls. As 30mg is less than 50mg the answer must be less than 2ml. The student may also be able to determine that the answer must be more than 1ml and therefore the correct dose must be between 1 and 2 ml). A safer method is to perform the calculation without a calculator and then use the calculator to check the answer.

Other things that students said they found useful in practice included keeping a notebook to write down formulas and notes on how to calculate medication doses. Always writing down medication calculations in the practice areas rather than trying to work them out in their head was also reported as helpful.

So it seems that there are a variety of teaching resources available to support the teaching of mathematics to student nurses and a range of strategies that student nurses can adopt to help them utilise their mathematics skills in practice. So why are student nurses not more confident in their ability? It would seem that the current learning and teaching strategies alone, whilst of significant value, are not enough. What is needed is a shift of focus away from assessments and the teaching to pass those assessments, which reflects an absolutist approach, to a more constructivist approach. This involves helping students address their anxieties and supporting them to engage in learning activities that lead to deeper and lifelong learning.

Chapter 8: Conclusions and Recommendations

The research questions that were addressed by this study were:-

- When, why and how does mathematics anxiety develop in some student nurses?
- What can be done to prevent, counteract or overcome this anxiety in order to improve student nurses' confidence in their numeracy skills?

423 students took part in a survey of one cohort of the BSc (Hons) Nursing programme during the first two weeks of their undergraduate studies. The results of this survey showed that 6.9% reported *Very High* mathematics anxiety, 28.6% reported *High* mathematics anxiety and 32.6% reported *Moderate* mathematics anxiety. So, overall 68.1% of students reported a moderate, high or very high level of anxiety which was higher than anticipated. However, it should be noted that the survey was conducted during the first two weeks of the students programme and therefore any anxieties are likely to be particularly heightened at this time. Subsequently nine of these students took part in in-depth interviews exploring their anxieties and their previous experiences related to mathematics.

The results of this study have shown that students of all ages, regardless of ability, can experience mathematics anxiety, and the age at which they report that anxiety starting varies widely. The students who were interviewed

claimed they started to experience mathematics anxiety at ages ranging from 5 to 16 years old, which suggests there is no one critical point at which this anxiety is likely to develop. This means that the teachers of all age groups, including those in further and higher education need to not only recognise that some students may be entering the programme with mathematics anxiety, but also be aware of the potential for mathematics anxiety to develop even in students who have previously appeared unconcerned about the subject.

The reasons given as to why mathematics anxiety had developed in some students were also varied. Two of the students who were interviewed did report specific incidents with a particular mathematics teacher, which they strongly felt were the root causes of their subsequent anxiety related to the subject. This aligns with the commonly held anecdotal view that mathematics anxiety is related to past negative experiences. However, the picture portrayed by the majority of the students who were interviewed was one of busy or stressed teachers who did not have the time or interest in them as individuals to help keep them on track. This aligns with Noddings' (2003) argument that teaching is relational and students learn best from teachers with whom they work closely and it matters to students whether or not they like or are liked by their teachers. The perception of some of the students that were interviewed was that it was how you fitted in that was important, which is supported by Di Maggio's (1982) theory that teachers communicate more easily with students who participate in elite status culture (fit in) and give them more attention. Therefore those teaching the students need to be

aware of how the relationship they develop with the student may be pivotal in increasing or decreasing the student's level of anxiety.

This is particularly important for those offering numeracy support, as they are often in the position of working with students on a one-to-one or small group basis. They need to recognise that the relationship they build with the student is key to the students' engagement with the subject, and that this relationship may be just as important, if not more so, than the content of teaching sessions. They need to try to teach with emotional intelligence, which means ensuring that the students are acknowledged and feel valued (Mortiboys 2012) as well as recognising when the student is uncertain or confused. It also involves recognising that there are other external factors that may affect a student's ability to learn at any given time. Many of the staff working with students in this area are already very knowledgeable about, and experienced in, *Teaching with Emotional Intelligence*, but on-going staff development opportunities related to further developing this skill are still important.

The students who were interviewed also talked about their families attitudes to mathematics. Although some parents had gone to the trouble of organising private mathematics tuition for them, others reported that their families did not appear unduly concerned about how they were succeeding in mathematics at school. Some reported that their parents and siblings were not particularly good at mathematics themselves and therefore did not expect them to be either. This in itself did not create anxiety at the time, but students reported that when they later learnt that they needed mathematics skills or

qualifications, their lack of ability and / or confidence in mathematics then created anxiety for them. The relationship with the teacher and input from the family aligns with Bourdieu's (1986) theory of cultural capital, and Matheson's (2006) theories related to cultural distance and optimal cultural distance and it was clear that some students did not perceive mathematics as being *for them*. However, only those who reported high or very high levels of mathematics anxiety were interviewed. Further research is needed to compare the experiences of those who report little or no mathematics anxiety, to see if their experiences related to teachers and families tend to be different to those reported here.

There were no clear answers as to how mathematics anxiety developed in the students that were interviewed. What was clear was that previous successes in mathematics did not appear to have reduced the anxiety for these students. All had achieved at least a GCSE grade C or equivalent in mathematics and some students with higher qualifications such as A-Level also still reported high levels of mathematics anxiety. It is generally assumed that success in a subject will increase the students' confidence in that subject and reduce their anxiety related to it, but this was not the case with mathematics for the students in this study. Studies by Hutton (1998b) and Macdonald et al (2013) have shown that GCSE mathematics is not a good indicator of a student's baseline ability in numeracy and this study has shown that it is unlikely to be a good indicator of a student's confidence in mathematics either. We therefore have to question why we still require a GCSE mathematics qualification (or an equivalent) as part of our entry criteria. A pre-entry numeracy test, that is already part of the admissions

process, might well be a much better indicator of whether the student has the potential to acquire the numeracy skills they need. It would certainly be a better indicator for the student of the type of numeracy skills they need to develop.

Five of the nine students that were interviewed referred to a sense of falling behind their peers or of not being able to do something that others could do. Others referred to a sense of *mystique* or *the unknown* related to mathematics and it was clear that language, or a lack of understanding of mathematical language, was an issue for several of the students interviewed. If, as previously argued, language is the vehicle of education (Matheson and Matheson 2000), then those teaching or supporting mathematics need to be aware of the importance of the language that they use and think carefully about the terminology, abbreviations and symbols that they use. A common understanding of language is critical, so the use of clear terminology that is understood by the learner is an important factor in an effective learning experience. This means teachers checking the students' understanding of the mathematical terminology that they use and even providing a glossary of relevant mathematical terms. The faculty could help to make the mathematics requirements of the course much clearer, by providing pre-course information about exactly what numeracy skills nurses need and what will be required of them throughout their programme of study.

The approach that students take to learning also appears to be an important factor in their relationship with mathematics. The results of this study suggest that students with high levels of mathematics anxiety are more likely to take

a surface approach to learning the subject, with a particular focus on what they need to pass examinations. This is evidenced by the students' reports that they tend to cram for examinations, which enables them to pass but often they cannot recall how to perform the same calculations a few weeks later. This would help to explain the students' lack of confidence despite their apparent ability, and the fact that they continue to seek support in the second and third years of their programme, for a level of mathematics in which they have previously demonstrated competence. The numeracy support for student nurses that is offered in university needs to shift away from the remedial style teaching of basic numeracy skills directly related to assessment, as this appears to be encouraging students to adopt or continue with a surface approach to the learning of these skills. Instead the focus should move more towards supporting students to recognise their abilities and understand both their mathematics anxiety and their learning approach to mathematics.

Tutorial time could be more effectively used to support students engaging with on-line resources and other support materials, encouraging them to become more independent learners. There are a range of excellent resources available to help students develop their numeracy skills particularly related to clinical placement and medication management, but we need to understand that some students with mathematics anxiety need initial support to engage with these resources. Race (2010) argues that in the current age of on-line resources the role of staff in higher education is no longer about giving students content but is about supporting their learning through guidance, feedback, assessment and recognizing achievement.

Therefore the small group and one-to-one tutorial time that we have available to us would be more usefully spent providing this support rather than simply revisiting the teaching of numeracy skills that the students will have inevitably received many times before. This support should include working with students on on-line and self-directed resources but with a view to gradually weaning them off tutor support to a point where they are able to use these resources independently. It is anticipated that such support would lead to a deeper approach to learning and the knowledge and skills gained would become better embedded, ultimately improving the student's confidence, developing independent learners and establishing the life-long learning approach to developing skills that are transferrable to the workplace.

Further research is needed to explore the experiences of those with low levels of mathematics anxiety to explore whether their experiences are different to those students studied here, in particular whether they report good relationships with their mathematics teachers and a family background where mathematics qualifications were highly valued, and learning mathematics was supported and encouraged. In retrospect, this study would have been improved if it had focussed on such a comparison. It would also be interesting to explore whether the anxiety levels of the students in this study change as they progress through their nursing programme, and there is the potential for this to be explored outside of this study.

Further study is also required using a modified version of the data collection tool. It is now recognised that the AMAS section of the data collection tool primarily consists of scenarios that directly relate to the absolutist philosophy

of mathematics and a behaviourist approach to teaching. Anderton and Wright (2012) argue that for some students, their experience of this approach to teaching and learning is so unpleasant that they develop a phobia of mathematics. It may well be the case that the high levels of mathematics anxiety reported in this study are partly due to the type of scenarios that were identified within the data collection tool. Whilst one statement was changed to reflect a real world scenario, the tool could be modified to include several more. The responses could then be compared to determine whether real world scenarios which reflect a fallibilist perspective engender a lower level of anxiety than those reflecting the absolutist perspective.

Finally further study will be needed to explore and evaluate whether changing the focus of numeracy support for student nurses, as suggested above, has any impact on improving their confidence in their numeracy skills. As a result of this study it is my intention to modify the mathematics support that is offered to students in the faculty in line with the recommendations above. Of course this will need to be carefully planned, closely monitored and thoroughly evaluated, and will inevitably form the basis of further research studies.

Reflection on the Research Process

As a result of undertaking this study, I have learnt a great deal about myself, and I feel I have developed a better understanding of the anxieties that some of our students demonstrate in relation to mathematics. I have gained a greater understanding of my own epistemological position and now recognise myself as a constructivist and a pragmatist. I also now recognise

that I have a strong affiliation with the fallibilist philosophy of mathematics, and believe that this will influence my approach to numeracy support in the future. I have a lot more confidence in myself and my role. In the past I have experienced discomfort in my role as a senior academic, having never been a university graduate in the traditional sense, but much of the educational theory I have explored has enabled me to rationalise and justify my position.

I intend to make changes to some of our current student support practices, despite the fact that they are often nominated for and win Good Practice awards. I intend to continue to raise the question of why we require a GCSE grade C or above in mathematics when it is clearly not a good indicator of the students' ability or confidence in the subject. I also intend to shift the focus of the numeracy support we offer away from the remedial style teaching of mathematical skills towards a more supportive engagement in supportive activities with a view to creating more independent learners. This will involve using more real-world resources but supporting students to engage with these. As mentioned above these changes need to be implemented carefully and gently in order not to further exacerbate student anxieties. They will also require extensive evaluation which is likely to form the basis of a further research study.

Throughout the study I made every effort to ensure rigour, by making the process as transparent as possible and by triangulating both the methods used and the data collected. This helped to increase the validity and reliability of the data and therefore the overall quality of the study. In retrospect the study would have been improved by including interviews with student who had low levels of mathematics anxiety to see if their experiences

differed from the students included here. As mentioned above I would also design a different data collection tool to include scenarios representing real world experiences of using mathematics in everyday life. However, this study has been valuable and will form the basis of changes to practice, as well as acting as a starting point for further study.

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Appendix 1. Letter inviting students to take part in the research study.

Dear Student

Re: Invitation to take part in a research study

My name is Gay Johnson and I work in the Personal Development Department (PDD). I would like to welcome you to the Faculty of Health and in particular to the Numeracy Support offered by the PDD.

Numeracy will be an important component of your course, as we need to ensure that you are safe and competent in skills such as medication calculations by the time you become a qualified nurse. In order to help you develop that competence there are a whole range of support resources available to you, and we are constantly working to develop these resources.

As part of this development I am currently conducting a doctoral level research study of students' anxiety levels related to numeracy and maths, and I would like to invite you to take part in this study. Participation will involve completing a short questionnaire related to how particular maths related tasks make you feel. The questionnaire will take approximately 5 minutes to complete and there will be time to do this in today's session.

Please note: you are under no obligation whatsoever to take part, and the support available to you will not be affected in any way if you decline. Feel free to look at the questionnaire before deciding, and if you do not wish to participate just return it blank.

If you do agree to take part, the questionnaire does ask you to include your name. This is so that your results can be returned to you on an individual basis, which may be helpful to you in that they may help you understand your relationship with maths a little better, and help you determine the support you need. Also in January next year, I will be asking for volunteers with high levels of maths anxiety to be interviewed about their experiences of maths. Please be assured that the section of the questionnaire kept for data analysis

will be completely anonymous. I will be the only person who handles the data. However, if you do not want your results returned, you can complete the questionnaire without including your name if you wish.

When I have completed my study I will invite you to a presentation of the findings and, if I successfully complete my doctorate, a copy of my completed dissertation will be available from the library.

Thank you for your time. I do hope you will agree to participate. If you have any questions please do not hesitate to ask

Gay Johnson

Personal Development Department

Room 261 Seacole /Tel: 0121 331 6146 / e-mail: gay.johnson@xxx.ac.uk

Appendix 2. Data Collection Tool,

The Data Collection Tool incorporates a modified version of the Abbreviated Maths Anxiety Scale (AMAS) + two additional sections.

Name:

(For return purposes only - this page will be removed from the rest of the document and returned to you with your results)

If you do not want your results returned then you do not need to include your name.

If you do not wish to take part in the study, just return the blank document. You do not need to tell me or anyone else whether you completed it or not

You do not need to complete this section – it will be completed and returned to you

Final Score

This score suggests that your numeracy anxiety level is:-

Score	Level of Anxiety	
0	No Anxiety	
1 - 9	Mild	
10 - 18	Moderate	
20 - 27	High	
28 - 36	Very High	

If you would like to discuss any aspect of numeracy, including numeracy anxiety and/or help with developing your numeracy skills, please contact me or any member of the Personal Development Department team.

Demographic Data.

Please tick the relevant boxes;

Are you Male? ☐

 Female? ☐

Which age band are you in?

18 – 20 years ☐

21 – 30 years ☐

31 - 40 years ☐

41 - 50 years ☐

51+ years ☐

Which of the following applies to you?

I have completed all of my education to date in the United Kingdom ☐

I have completed part of my education to date in the United Kingdom ☐

I have not previously completed any education in the United Kingdom ☐

If you completed all or part of your education outside of the UK please state in which country or countries you were educated.

.....
.....

What is the highest level maths qualification you have achieved to date (including grade)?
E.g. GSCE Maths grade C

.....
.....

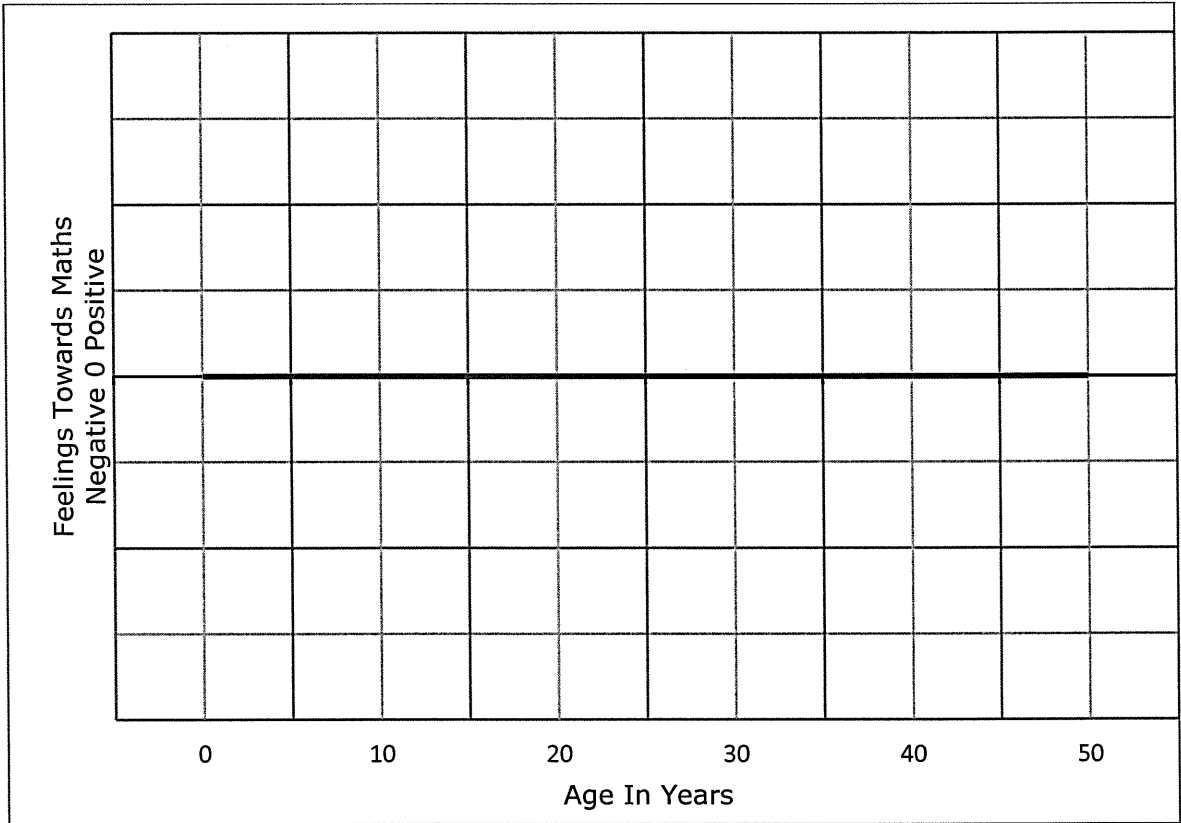
Please turn over the page

Please rate each item in terms of how anxious you would feel during the event specified. Tick the appropriate box

	No Anxiety (0)	Little Anxiety (1)	Some Anxiety (2)	Moderate Anxiety (3)	High Anxiety (4)
Having to use maths in everyday situations e.g. dividing a restaurant bill.					
Thinking about a forthcoming maths test one day before.					
Taking a maths exam.					
Watching a teacher work out a long division question on the board					
Listening to a lecture in maths.					
Being given homework consisting of many difficult maths problems which is due in next class.					
Listening to another student explain a maths formula.					
Being given a maths quiz in class.					
Starting a new subject area in maths.					

Please turn over the page

Please draw a line on the graph below showing how you have felt about maths over your lifespan. The horizontal axis (going across the page) represents your age in years. The vertical axis (going up and down the page) represents how positive or negative you have felt about maths. The middle line represents a neutral level, i.e. neither positive nor negative. The higher above this line you go indicates the more positive you have felt about maths. The lower below the line you go indicates the more negative you have felt.



Please state in one word, phrase or sentence how maths makes you feel.

.....

.....

Thank You!

Appendix 3: Original AMAS Assessment Tool (Hopko et al 2003)

Abbreviated Math Anxiety Scale (AMAS)

Please rate each item in terms of how anxious you would feel during the event specified. Use the following scale and record your answer in the space to the left of the item:

Scale:

1 = Low Anxiety

2 = Some Anxiety

3 = Moderate Anxiety

4 = Quite a bit of Anxiety

5 = High Anxiety

- _____ 1. Having to use the tables in the back of a math book.
- _____ 2. Thinking about an upcoming math test one day before.
- _____ 3. Watching a teacher work an algebraic equation on the blackboard.
- _____ 4. Taking an examination in a math course.
- _____ 5. Being given a homework assignment of many difficult problems which is due the next class meeting.
- _____ 6. Listening to a lecture in math class.
- _____ 7. Listening to another student explain a math formula.
- _____ 8. Being given a "pop" quiz in a math class.
- _____ 9. Starting a new chapter in a math book.

Appendix 4: Permission from Professor Hopko to use AMAS Assessment tool.

From: Hopko, Derek R [mailto:dhopko@utk.edu]
Sent: 20 September 2010 17:43
To: Gay Johnson
Subject: RE: The Abbreviated Math Anxiety Scale

Hi Gay:
Your research sounds very interesting! Yes, you have my permission. Attached is the scale and the associated article.

Best,
Derek

Derek R. Hopko, Ph.D.
Associate Professor
The University of Tennessee
Department of Psychology
307 Austin Peay Building
Knoxville, TN 37996-0900
PH: (865) 974-3368
FAX: (865) 974-3330

-----Original Message-----

From: Gay Johnson [mailto:Gay.Johnson@xxx.ac.uk]
Sent: Mon 9/20/2010 11:48 AM
To: Hopko, Derek R
Subject: The Abbreviated Math Anxiety Scale

Dear Professor Hopko

My name is Gay Johnson and I am a Senior Academic in the Faculty of Health, Xxxx University, England. I am currently starting to study for a Doctorate in Education, for which I want to undertake a study of the origins of numeracy anxiety in healthcare students. I want to screen a cohort of students to assess levels of numeracy anxiety and then interview a number who have high anxiety levels to identify if there are any significant life experiences which they associate with their anxiety. In order to do this I need a reliable measurement tool and I am particularly interested in your Abbreviated Math Anxiety Scale. I am therefore writing firstly for your permission to use the scale, and if you agree, for information on how to obtain and use it

Gay Johnson
Head of Personal Development Department
Faculty of Health, Xxxx University
Tel: xxxxxxxxx

Appendix 5 – Approval from the Open University's Human Research Ethics Committee (HREC)

From: D.Banks [d.banks@open.ac.uk]
Sent: 30 June 2011 11:42
To: Gay Johnson
Cc: Research-Ethics; Research-REC-Review; D.Banks
Subject: HREC/11/#965/1

From Dr Duncan Banks
Chair, The Open University Human Research Ethics Committee
Email d.banks@open.ac.uk
Extension 59198
To Gay Johnson, FELS.
Subject '*The Origins of Numeracy Anxiety in Healthcare Students.*'
Ref HREC/11/#965/1
Red form
Submitted 3 June 2011
Date 30 June 2011

Memorandum

This memorandum is to confirm that the research protocol for the above-named research project, as submitted for ethics review, **is approved** by the Open University Human Research Ethics Committee. However, before you commence your studies you will need to address the following questions from the reviewers;

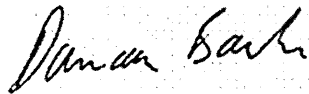
1. What is the relationship between you and the students taking part in the study? Will students feel that by contributing to the research in some way it contributes to their own programme of study?
2. The methodology employed in the data collection and analysis has the personal data removed but that photocopies are made of the originals. However, this leaves the potential for identifiable data to exist. Could you comment on this? Your supervisor should review the protocol to see if there can be some mechanism for controlling and protecting the data whilst it is identifiable to a participant.
3. Although there is no consent form as such, the completion of the questionnaire by a participant may be taken as consent and therefore it would be preferable to include a specific consent paragraph as part of the information sheet and at the beginning of the questionnaire.

4. How will you know who to approach next year in the second part of the research? It would be appropriate for you to prepare a reminder leaflet to be given to the participants next year to gain formal consent.
5. If questionnaire data is anonymised before storage, how can you get in touch with those who scored highly?
6. What is the potential for you to come across very severe anxiety?
7. It is suggested that you change 'invited to volunteer' to being asked to 'participate'.
8. Could you add a second contact name in case participants want to talk to someone else about the research?

Please forward your comments and any other communications regarding this approval to Research-REC-Review@open.ac.uk.

At the conclusion of your project, by the date that you stated in your application, the Committee would like to receive a summary report on the progress of this project, any ethical issues that have arisen and how they have been dealt with.

Regards,



Duncan Banks
Chair OU HREC

-

The Open University is incorporated by Royal Charter (RC 000391), an exempt charity in England & Wales and a charity registered in Scotland (SC 038302).

From: Gay Johnson [mailto:Gay.Johnson@xxx.ac.uk]
Sent: 16 August 2011 18:36
To: Research-REC-Review@open.ac.uk
Subject: RE: HREC/11/#965/1

Dear Dr Banks and Panel

Please find attached my response to comments and suggestions below

Thank You for your time and help

Gay Johnson

M1315258

From: Research-REC-Review [mailto:research-rec-review@open.ac.uk]
Sent: 27 January 2012 11:05
To: Gay Johnson; 'Research-REC-Review@open.ac.uk'
Cc: D.Banks
Subject: RE: HREC/11/#965/1

Dear Gay,

For some reason we have been unable to locate my response to your enquiry. For our mutual records I can confirm that you have adequately addressed all the comments received from our reviewers.

Regards,

Dr Duncan Banks
HREC Chair

Appendix 6: Approval from Faculty's Sponsorship and Indemnity Committee.

From: XXXXXXXX XXXXXXXX **On Behalf Of** Health Academic Sponsorship
Sent: 17 November 2010 14:10
To: Gay Johnson
Cc: XXXXXXX
Subject: Academic Sponsorship

Dear Gay

The Academic Sponsorship Committee met today to discuss your application. We are happy to issue a letter of indemnity for your project and would like to take the opportunity to commend you for submitting an excellent application, which was clear, concise and informative.

We wish you success in your study.

Academic Sponsorship group

XXXXXXXXXX

Research Centre Administrative Officer/Committee Secretary

XXXXXXX University

Faculty of Health

Centre for Health and Social Care Research

Appendix 7: Results obtained from Pilot Study (Excel spreadsheet)

Student	Gender	age group	education in UK	other education	Highest Maths Qual.	Level
1	f	21-30	all		GCSE B	Mod
2	f	18-20	all		GCSE C	High
3	f	41-50	all		O-Level C	High
4	f	18-20	all		GCSE B	Mod
5	m	18-20	all		A LEVEL A*	none
6	f	21-30	all		GCSE C	high
7	m	21-30	part	nigeria	School Cert	mod
8	f	51+	all		CSE 1	mod
9	f	31-40	part	africa	GCSE C	very
10	m	18-20	all		GCSE C	high
11	m	18-20	all		A Level C	mild
12	f	21-30	all		GCSE C	Very
13	f	18-20	all		GCSE A*	none
14	f	41-50	part	holland	School Cert	high
15	m	21-30	all		GCSE B	none
16	m	21-30	all		GCSE B	mod
17	m	18-20	all		GCSE C	High
18	m	31-40	part	pakistan	O-LEVEL B	mod
19	f	21-30	all		GCSE A	Mild
20	m	41-50	part	iran	GCSE C	Mild
21	f	18-20	all		A Level D	mild
22	f	18-20	all		GCSE C	high
23	f	31-40	part	phillipines	KEY SKILLS LEVEL 2	Mod

Student Graph

- 1 marked dip from pos to neg mid teens
- 2 dip in teens
- 3 positive til early teens then decline
- 4 fluctuating between pos and neg
- 5 steady increase in positive
- 6 all increasingly negative
- 7 up and down pos to neg
- 8 stable - slightly above positive
- 9 all negative but steady
- 10 marked dip mid teens
- 11 dip to negative in teens
- 12 positive to start then steady decline
- 13 increasingly positive
- 14 marked dip from pos to neg mid teens
- 15 all positive
- 16 marked dip from pos to neg mid teens
- 17 marked dip from pos to neg mid teens
- 18 all negative
- 19 steady line positive
- 20 slight dip from pos to neg in teens
- 21 up and down pos to neg
- 22 definite dip from pos to neg in tens
- 23 steady decline from start

student

Feelings

- 1 it makes me feel thick

- 2 I'd rather not think about it thanks
- 3 like I want to cry
- 4 uncomfortable
- 5 I love it
- 6 its the one thing that I worry about in the course - I know I can do the rest
- 7 its a real groany thing
- 8 I really don't like it
- 9 Sick
- 10 like you've eaten an elephant
- 11 its just something you have to concentrate on - you cant take it for granted
- 12 I feel like a five year old
- 13 indifferent
- 14 i get really worried about it
- 15 Its not something that bothers me. I really cant see why some people are so spooked
- 16 it makes me feel sick
- 17 I want to be a nurse - get me out of here
- 18 i get a really sinking feeling
- 19 I don't really feel anything strong
- 20 its not what I'd choose but its ok when I have to do it
- 21 a necessary evil
- 22 I feel panicky
- 23 I just don't like it

Appendix 8: Questions / themes for Interview

Demographic Data

- o gender,
- o age category
- o educational history
- o highest maths qualification

(What are your) Earliest memories of using numbers?
(Prompts if needed – counting, measuring, cooking? Were these good or bad memories / experiences?)

Family attitudes to maths
(are your parents / siblings good at maths? Did they encourage you?)

Can you recall how were you introduced to or taught maths when you first started school?

How did you feel about maths at this time?

How did your feelings change over time (if at all)?

When do you think your anxiety about maths started?

What do you think causes / caused this anxiety?

Are there any specific maths or numeracy related incidents that you can recall, either in school or out of school? Are they positive or negative?
(prompt for more than one if appropriate)

How did you get on with your maths teachers?

How do you feel about maths or numeracy assessments and exams?

Do you feel this way about all exams or is maths different to other exams you have to take?

How do you feel about numeracy or maths now?

(If anxiety or similar mentioned) Do you experience any 'physical symptoms'?

Why do you think you feel that way? (if appropriate)

In what way do you think the way you feel affects your maths or numeracy ability?

Is there anything that you feel does or could help you become less anxious about maths?

Is there anything else you would like to tell me about your past experiences of numeracy or maths?